VOLUME 66 • AUGUST 1957 • NUMBER 2

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OTOLARYNGOLOGY

Aerotitis Media
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Histopathology of Stapes Ankylosis
Edmund P. Fowler Jr.

The Larynx in Leprosy
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Checks, money orders, and drafts should be made payable to the American Medical Association, 535 North Dearborn Street, Chicago 10.

AMERICAN MEDICAL ASSOCIATION Publication

Published monthly by the AMERICAN MEDICAL ASSOCIATION. Editorial and Circulation Offices: 535 North Dearborn Street, Chicago 10, Illinois. Publication Office: Thompson Lane, Box 539, Nashville 1, Tennessee. Change of Address: Notice to the circulation office should state whether or not change is permanent and should include the old address. Six weeks' notice is required to effect a change of address. Second-class mail privileges authorized at Nashville, Tenn., Aug. 6, 1956.

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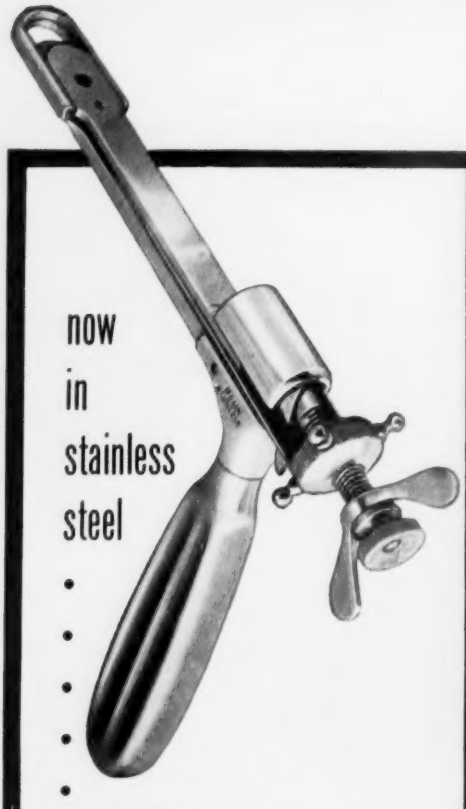

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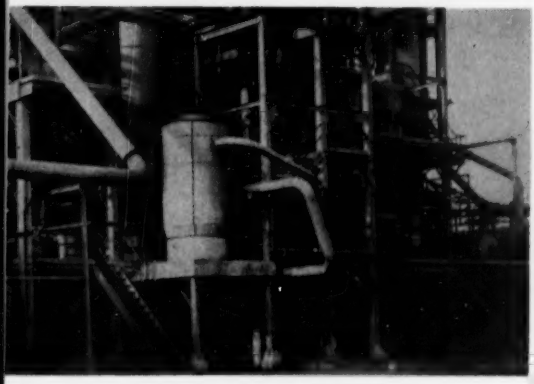

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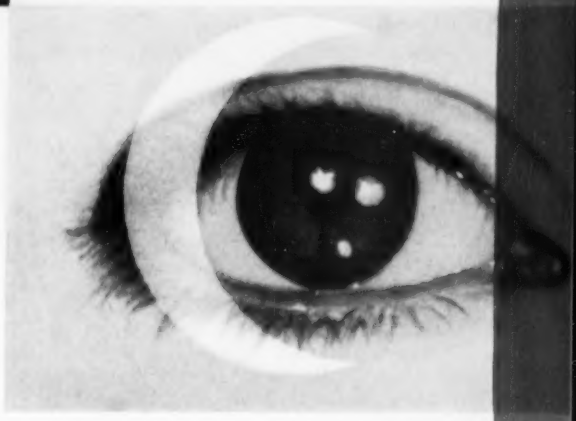

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A.M.A. ARCHIVES OF
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Aerotitis Media

DAVID CHARLES SCHECHTER, M.D., Philadelphia

Introduction

In the 15th century, Leonardo da Vinci, whose genius shone in both art and science, drew designs of various types of "heavier-than-air flight machines," some of which closely resemble those in use today. Medical investigations in aeronautics were initiated soon after the Montgolfier brothers invented the balloon in 1783. A sheep, a duck, and a rooster were sent up in a balloon at Versailles, and were found to be none the worse for their experience. In October, 1783, the first actual flight was made by man. Pilâtre de Rozier and the Marquis d'Arlandes ascended to 3000 ft. in a huge, smoke-filled balloon. In December of the same year, Charles was raised aloft to 10,500 ft. and complained of severe pain in his right ear and jaw, the first recorded physical discomfort associated with flight. Two years later, Dr. John Jeffreys, of Boston, flew with the Frenchman Blanchard from Dover, England, to Calais, France, in a hydrogen-filled balloon. In 1862, Glaisher and Coxwell ascended in a balloon to an altitude of 29,000 ft., and Glaisher recorded loss of vision and auditory acuity, and paralysis of his arms and legs. Glaisher's descriptions stimulated the French physiologist Paul Bert to begin his brilliant investigations on the effect of decreased and increased barometric pressures. Sir George Cayley devised a fixed wing glider that could raise him from the ground, but modern aviation dates from the successful flight of the Wright brothers' airplane at Kitty Hawk, N. C., in December, 1903.

The outbreak of World War I prompted much interest and caused great developments in aviation medicine, especially after analysis of the Allied casualty list for the first year of hostilities revealed that of every 100 fliers that perished only 2 were killed by the enemy, whereas 8 died from airplane defects and 90 from physical deficiencies of the flier!

In 1920, Scott[1] reported the results of his examination of a large number of British fliers. He found no evidence of direct injury to the middle ear, but recognized innumerable instances in which there were changes in the middle ear due to barometric pressure variations. He warned that aviators should not fly with a head cold, sore throat, or when unable to inflate the Eustachian tube at will.

In 1900, Heller, Mager, and von Schrötter[2] published an extensive pioneer study on the problem of otitic barotrauma, with particular reference to the occupational hazards of the caisson worker. It was not until 1937, however, that the condition was described by Armstrong and Heim[3] as a distinct clinical entity, and named aero-otitis media. It has been known also as aviation pressure deafness, tontrauma, baroscopic condition, and acute otitic barotrauma.[4] The term most commonly used today is aerotitis media.[5-8]

Accepted for publication Feb. 28, 1957.
Jefferson Medical College Hospital.

A vast amount of literature on the subject has accumulated, based on research activities during World War II. The condition has gained unprecedented interest, with the strides made in commercial air transport, jet aviation, and submarines. The purpose of this dissertation is to review some of the salient features of etiology, symptomatology, and management.

General Considerations

An appreciation of the dynamics of barometric pressure change upon the middle ear is a prerequisite for the proper understanding of the pathogenesis of aerotitis media.

The density of the atmosphere which envelopes the surface of the earth decreases with altitude according to a curvilinear gradient. Any closed gas-containing cavity which is elastic or has elastic walls will expand during ascent, owing to the relative decrease in the density of the ambient air. The degree of expansion is contingent upon the elastic limits of the walls of the container, and to some extent upon the moisture content of the enclosed gas. Theoretically, if the walls are perfectly elastic, the volume will be doubled at about 18,000 ft., quadrupled at approximately 34,000 ft., and will expand eightfold at about 48,000 ft. During descent, such a cavity will contract, attaining its initial volume as the earth is touched, providing gas has neither escaped nor been absorbed through the walls.

The middle ear may be visualized as a partially elastic chamber, due to the mobility and resiliency of the tympanic membrane and to the very minor degree of elasticity of the mucoperiosteum of the pneumatic spaces. It communicates with the exterior only through the Eustachian tube. It is a closed cavity only if the Eustachian tube is occluded by some pathologic process, under which circumstances ascent reduces the restricting influence of the outside atmosphere, and the elastic elements are forced outward. Since the tympanic membrane is the most resilient of the elements, it will bulge externally to the limits of its elasticity as higher altitudes are reached. During descent, it will slowly return to its original position. This situation applies only if the drum is intact and if the tube is occluded, which situation is the predisposing one to aerotitis media. Where perforation of the drum or a wide open tube is existent, unrestricted gaseous flow occurs during altitudinal changes.

The Eustachian tube acts as a one-way flutter-valve adjustor to pressure differentials between the gas of the middle ear and that of the outside. It allows the egress of air from the middle ear more readily than its admission from the nasopharynx.[9,10] Ordinarily, the tube remains closed except during acts of swallowing, yawning, thrusting the lower jaw forward, or similar maneuvers.[11] While the most important function of the normal Eustachian tube is in ventilation of the middle ear, it likewise effects drainage of accumulated fluids from the middle ear, and obviates autophony[12] by sealing off the pharynx from the tympanic cavity.

The anatomic features and histologic structure of the Eustachian tube have been elaborated upon in great detail,[13-19] and a review of such studies is beyond the scope of this paper. Suffice it to emphasize that a knowledge of the configuration of the tube and of the location and relations of the tubal orifice is necessary to any physician treating aerotitis media, in order to enhance the effectiveness of catheterization and avoid traumatization of soft tissues.[19,20] Not infrequently, scarring and adhesions resulting from inexpert adenoidectomy, bougienage, or overzealous catheterization distort the tubal aperture considerably.[21] The richly vascular mucosa becomes swollen and engorged in allergy and upper respiratory infections, which may result in marked interference with tubal function. Moreover, impingement of lymphoid tissue in or about the tubal wall or orifice, such as hypertrophied tonsils and adenoids, islets of lymphoid tissue, or hypertrophied turbinates, may re-

duce the efficiency of the opening mechanism or, if sufficient, entirely precludes opening.

Hyperemia or edema of the structures, the viscosity of the local secretions, pus and detritus in the tube, polypoid masses, anatomic abnormalities, dental malocclusion, nasopharyngeal tumors, deformity of the lower jaw, and paralysis of the pharyngeal musculature may have a similar adverse influence.

Etiology

Armstrong and Heim originally defined aerotitis media as "an acute or chronic traumatic inflammation of the middle ear caused by a pressure differential between the air in the tympanic cavity and that of the surrounding atmosphere."[3] The noninfectious character of this entity merits emphasis. Only in rare instances is infection superimposed as a complication.

The etiologic aspects of aerotitis media have already been touched upon in general terms in the preceding discussion. It is generally agreed that the condition arises as a direct result of malfunction of the Eustachian tube during exposure to changes in barometric pressure. Some more specific features will be reviewed.

Permanent or cicatricial Eustachian stenosis is responsible actually for only an occasional case of barotrauma,[22] but should be suspected in persons with a history of repeated attacks of aerotitis in the absence of any allergy or upper respiratory infection.

Temporary Eustachian tube occlusion is usually the result of nonspecific acute or chronic infection or allergic reactions of the nose, sinuses, or nasopharynx.[4,5,23-26] Other workers disclaim any direct correlation between the incidence of colds and otitic barotrauma,[22,27] and decry the "grounding" of a person because of coryza or a mild pharyngitis.

The problem attains its greatest importance during combat in that it may result in needlessly augmenting the number of noneffective personnel. It would seem prudent, until more statistics are obtained, to possibly curtail flying in persons with moderately severe upper respiratory infections, unless these effects can be overcome by adequate ventilation of their ears. With reference to allergy, however, additional data are available to incriminate it as a contributory factor to the inception of aerotitis.[4,25,26,28]

A positive correlation is believed to exist between the incidence of aerotitis media and the presence of hypertrophied lymphoid tissue around the tubal orifice,[4,7,28-30] and has been the basis of the irradiation treatment of hyperplastic lymphoid tissue about the Eustachian tube meatus.[31,32] Some workers dispute this relationship.[33]

Subsequent to Costen's[13] and Willhelmy's[34] work demonstrating compression of the Eustachian tube by the soft tissues in dental malocclusion, the prevailing impression is that faulty closure of the jaws plays a small but definite role in tubal obstruction.[4,7,22,35,36] Where feasible, dental corrective measures have given very good results.[7]

Other anatomic factors play relatively minor roles in the etiology of otitic barotrauma. Mention should be made, however, of Fowler's statement[36] that previous aural pathology may contribute to the development of aerotitis. This is difficult to corroborate, since attacks may have occurred due to exposure of subjects to pressure changes before return of middle-ear tissues to normalcy after aural disease.

Lastly, aerotitis media may be produced or aggravated by absorption of oxygen from the middle ear. This explains the delayed, or "secondary," aerotitis occurring in aviators who have been breathing pure oxygen over long descents, and in whom the onset of symptoms occurs several hours later.[37-39]

Toxic effects are practically never produced by breathing oxygen below a concentration of 60% of one atmosphere.[40,41] While the low temperatures existing at high altitudes do not affect the incidence of aerotitis,[42] the duration of the action of negative

pressure in the middle ear appears to be important.[43]

Symptoms and Signs

Aerotitis media may be unilateral or bilateral. The numbers complaining of monaural or of binaural symptoms are about equal, although objective findings are often observed in asymptomatic ears.[44,45] The condition may be mild or severe, acute or chronic, depending on the degree and frequency of the traumatic insult, and on the etiology of the tubal occlusion. It may occur during or immediately following flight. As has been mentioned, it may be delayed for several hours after flight. It usually takes place on descent. It is recorded to have occurred in rare instances on ascent, ostensibly due to congestion of polypoid flaps in the middle-ear ostium of the Eustachian tube.[24,22]

In the mildest type of acute aerotitis, slight retraction of the eardrum and vascular engorgement of the vessels along the handle of the malleus occur, together with some alteration of the light reflex. The only symptoms are a mild sensation of fullness, and possibly slight pain. Since the tubal block is rarely great following such circumstances, equalization of pressure and prompt recovery after flight is the rule.

In those instances where occlusion is more complete and pressure differentials greater, retraction is more pronounced and the entire drum becomes severely inflamed. There may be small submucosal hemorrhages scattered about the membrane, and bubbles of serosanguineous fluid are frequently seen through its translucent portions. Subjectively, stabbing pain, low-pitched tinnitus, and conduction deafness are present.

In the severest categories of acute aerotitis media blood usually pools in the most dependent portion of the tympanic cavity. Rupture of the drum occurs rarely, unless the structure has been weakened by disease or if the pressure differential is very great. The symptomatology here is usually pronounced.

The term chronic aerotitis media, as commonly used, refers to those cases in which aural and tubal structures have been more or less permanently altered by severe or repeated barotraumatic exposures. Persons so afflicted cannot fly with comfort unless the offending tubal pathology is corrected.

Deafness is the most frequent complaint elicited in aerotitis, but is often overshadowed by pain. It is to be differentiated from the acoustic loss following prolonged exposure to noise. It is usually of the conductive type, transitory, and reversible, and is believed to result from immobilization of the tympanic membrane, fixation of the ossicular chain, and edema and congestion of the mucous membrane of the middle ear. In rare instances, a perceptive type of deafness may occur which is irreversible and presumably due to alteration of intralabyrinthine pressure, with hemorrhage. The degree of deafness is more or less proportional to the magnitude of the pressure differential and the amount of functional or pathologic involvement. Audiometric curves present a variety of patterns. In some cases, hearing loss is limited largely to the lower frequencies; in others, to all the frequencies, and, in some, exclusively to the higher frequencies. In general, hearing for the lower frequencies seems to be depressed first. As fluid is drawn into the middle-ear cavity, the high frequencies become more and more involved.

The onset of pain may be gradual or sudden. It may be mild, but is usually stabbing in character. The intensity of the pain does not necessarily parallel the objective findings. Great pain may occur without associated middle-ear changes; contrariwise, minimal or even no pain has been reported with actual rupture of the eardrum.[4] Regardless of the severity of the pain, it is usually relieved upon ventilation of the tympanic cavity.

There are always sensations of fullness and stuffiness in the ears for variable periods of time. These are accompanied by a concomitant feeling of fluid in the involved

ear.[46] Tinnitus occurs not infrequently, but is usually not a predominant symptom. Vertigo following severe barotraumatic insult occurs occasionally, is usually unilateral,[47] and may be severe. It is particularly perilous if it affects a person while he is piloting an aircraft. Bubbling sounds in the affected ear on blowing the nose, swallowing, or yawning are often present. Another disagreeable experience is the occasional appearance of autophony, in which the person's own voice and respiratory noises sound unusually loud to him.

Diagnosis

One needs hardly to be reminded that the first step in diagnosis must cover the ground encompassed in every thorough initial examination. A painstaking and careful history and physical survey and such additional special procedures as may be suggested are prerequisites. The diagnosis of aerotitis media is usually readily made on the basis of the history and otoscopic inspection.

Otoscopy is the most useful single diagnostic aid, and reveals changes varying from slight retraction with hyperemia of the pars flaccida and along the handle of the malleus to hemorrhage in the tympanic cavity with or without traumatic perforation.[4,5,48] According to Teed's classification,[26] Grade 1 aerotitis shows retraction with redness of Shrapnell's membrane and along the handle of the malleus; Grade 2, retraction with redness of the entire drumhead; Grade 3, the same plus evidence of fluid in the middle ear, and Grade 4, hemotympanum and/or perforation.

Nasopharyngoscopy is essential for determining the etiological basis of tubal obstruction. Examination of the upper air passages with particular reference to the nasopharynx and to Eustachia tube function should be routine in all cases. Likewise, audiometry will aid in establishing the type of deafness present.

Because of the direct communication between the mastoid air cells and the middle ear, the presence of fluid in these cells may be observed radiologically.[4] Such clouding of the mastoid cells requires a minimum of approximately one month for complete resolution. Since roentgenological examination of the mastoid is neither of diagnostic nor prognostic value in individual patients, the use of this modality does not appear to be warranted as a routine procedure.[23]

Differential Diagnosis

External otitis (including aerotitis externa), acute suppurative otitis media, acute secretory otitis media (otitis media with effusion), and myringitis bullosa hemorrhagica must all be differentiated from acute aerotitis media.[49] In each case, a history of recent exposure to pressure changes is more indicative of aerotitis media.

Pathology

Animal experimentation has disclosed that the pathologic changes in aerotitis are primarily vascular in nature.[4,50] The pathophysiologic sequence of events is probably as follows: The extreme negative pressure or vacuum inside the occluded tympanic cavity draws the structures of the drum inward to such an extent that there is a degree of separation of the mucosal and fibrous layers, with subsequent edema and hemorrhage between the structures. The vacuum of the cavity sucks serosanguineous fluid from the lining mucosa. If great enough, it may cause rupture of small mucosal blood vessels, hemorrhage which later organizes. Mucosal edema and submucosal hemorrhage may occur singly or together; the hemorrhagic areas vary from tiny petechiae to large confluent areas. Fluid and blood are space-filling; therefore, their presence decreases the negative pressure differential.[24] Bacteriologic studies have shown these aspirated fluids to be sterile.[51]

Complications

Deafness, though the commonest symptom of aerotitis media, is usually mild and transient. It may become severe if an initial lesion is treated casually, or if a person is exposed to repeated pressure changes before complete recovery from a previous acute at-

tack has been allowed to take place. It is necessary to recognize that, in some instances, the various pathologic sequelae of aerotitis media may produce irreparable damage, both to the ear structures and to hearing. Blood in the tympanic cavity and the related pneumatic spaces may become organized. Fibrous adhesions may form between the ossicles or between the latter and other middle-ear structures.

Hemorrhage into the substance of the eardrum at times produces impedance to sound transmission. Many observers have noted clinically that aviators with considerable flying time have thickened tympanic membranes, presumably the sequel of repeated insults to the middle ear. Intralabyrinthine bleeding, though very infrequent, can result in severe deafness and marked vertigo of the Ménière type. It is quite possible that injury to the epithelium of the Eustachian tube may cause permanent changes thereof.

Otorrhea is a very uncommon complication of barotrauma.[44] Persons with subclinical acute aerotitis media subjected to repeated insults before restitution of middle-ear structures to normal may be more susceptible to otitic complications than persons with normal middle ears.[52]

Prognosis

The prognosis in cases of otitic barotrauma is dependent upon the rapidity with which treatment is initiated following exposure, its adequacy, and the allowance of an appropriate interval for complete recovery to occur. The inception of sequelae will be governed, in part, by the severity of the injurious pressure differential.

Generally speaking, the prognosis is fairly good.

Treatment

There are three components in the management of aerotitis media, namely, preventive measures, active therapy, and correction of contributing etiologic factures. These features will be discussed in the order given.

Prevention.—Proper indoctrination in the act of autoinflation is the single most important feature of prevention, a diminishing incidence of aerotitis being commensurate in terms of more trained personnel.[22,52,53]

Yawning, swallowing, and jutting out of the jaw are the most frequently used methods of ventilating the middle ear in flight. Another exercise is a grinding movement of the lower jaw. In Toynbee's maneuver, the subject swallows with the mouth and nose closed. Valsalva's maneuver is used by many otologists as a criterion of the ability of a person to "clear the ears"; it involves forceful expiration through the nose, with the mouth and nose closed. Frenzel's pharyngeal pressure maneuver is even more effective than the Valsalva; it consists of compression of the air in the pharynx by the muscles of the floor of the mouth and tongue, with the nostrils and glottis closed.

If the average person swallows at each 200 to 300 ft. during descent, little difficulty will ensue unless some pathologic process is present. During sleep, sedation, or coma, frequency of swallowing is greatly decreased, thereby predisposing to aerotitis. In many persons, postural attitudes, such as one asumes while reclining or by allowing the head to droop forward, backward, or to one side, will suppress ventilation sufficiently to contribute to blockage of one or both tubes. Carelessness, preoccupation, inattentiveness, and inexperience abet aerotitis. Ideally, these factors should be combated effectively by thorough instruction; but while this may be attained satisfactorily in military personnel, such an educational program is considerably more difficult to institute in the case of persons in commercial aircraft, for obvious reasons. On sleeper planes, it is advisable to awaken passengers during descent so as to avoid "locking" of the Eustachian tube. A commendable practice is that of feeding infants during descent so as to make them swallow more frequently. Chewing gum, sipping fluids, and similar procedures may aid persons who

have difficulty mastering other easy maneuvers.

Whenever possible, it is advisable that a flier or prospective airline passenger with an acute upper respiratory infection be "grounded" temporarily until the condition improves. Persons with allergies, chronic tonsillitis, or sinusitis should abstain from flying and have these situations corrected, unless they are mild or asymptomatic. Bateman [54] has pointed out that an active sinusitis in flying personnel may produce symptoms in the air although remaining symptom-free on the ground, and the symptoms of an active sinusitis may be expected to be aggravated by flying. It warrants reiteration, also, that any person who has had a recent acute attack of aerotitis should postpone flying until the middle-ear tissues have returned to complete normalcy.

Where persons, such as the military personnel, can be subjected to physical examination, emphasis should be placed upon normal Eustachian tube function. Otoscopy and nasopharyngoscopy must be thorough. Many authorities stress that failure to perform the Valsalva or similar maneuvers initially is not proof of tubal malfunction, and should not disqualify one for flying training, since it does not necessarily imply that the person will not be able to autoinflate successfully in flight.

Various devices have been employed for determining the presence of tubal insufficiency. Thus, indirect evidence of a pressure difference on the two sides of the tympanic membrane can be obtained by use of an instrument known as the pneumophone.[55] Inflation of each tube separately can be done through a catheter, or of both tubes together by means of a Politzer bag or some other source of pressure. Politzer's method is used most commonly, but yields only a rough estimate of the degree of tubal patency. Other modifications [11,56,57] provide quantitative evaluation of tubal function, whereby the tympanic cavity may be inflated by using just the amount of pressure necessary rather than the uncontrolled excessive pressure introduced by the Politzer bag.

The pressurization of modern aircraft cabins is probably the most important of recent developments in reducing the incidence of aerotitis media. This engineering advancement has been a significant contribution to high-level flights. Only a few planes of the smaller combat type are not pressurized, since in these cases streamlining and lightness may be militated against by extra equipment. In many of the present commercial aircraft, cabin pressures are maintained at 4000 to 6000 ft. under normal cruising conditions, and may be greater when flying at storm-evading heights.[58] Pressurization is maintained at the equivalent of ground level only until altitudes of 8000 to 9000 ft. are reached; to ascend above this level and not endanger the aircraft structure, the cabin pressure must be decreased, frequently to cabin levels equivalent to 8000 ft. of altitude. Thus during employment of the usual high-altitude flight pattern, the airplane occupant is exposed to barometric pressure variations similar to those experienced in low-level flights of altitudes ranging from sea level up to 8000 ft. In military aircraft, although explosive decompression offers but slight hazard to the middle ear, rapid recompression remains a very real potential cause of aerotitis. Fighter pilots change pressure frequently, and must be alert in making the necessary adjustments to these variations. The rate of descent is ordinarily no problem in commercial airplanes, but necessitates repeated ventilation of the ears in fliers of jet aircraft.

Active Therapy.—In the majority of cases of acute aerotitis media symptoms are mild, pain subsides early, and either no treatment or a minimum of conservative therapy is necessary. Resumption of flying should be avoided until otoscope findings reveal complete recovery.

The earlier the initiation of active treatment in frank cases of otitic barotrauma, the simpler and more effective the thera-

peutic measures will be. The primary objectives of treatment have been enunciated by Campbell.[24] They include the following: (*a*) relief of tubal obstruction, (*b*) neutralization of the vacuum effect by the introduction of air under positive pressure into the tympanic cavity, and (*c*) preventing recurrence of the vacuum effect.

The ideal treatment is simulated reascent in a pressure chamber to the level at which successful aeration is achieved, this being followed by descent at a rate slow enough to enable the patient to keep his ears cleared until ground level is reached.

Since the aforementioned method is not available to passengers of commercial aircraft, the next treatment of choice is shrinkage of the nasopharyngeal tissues followed by artificial inflation of the middle ear. Vasoconstriction may be effected by the use of nose drops or sprays. The Proetz displacement technique[39,59] may be used to good advantage. Excessive nasal secretions should be freed or drawn back into the pharynx, since forceful blowing of the nose or artificial inflation may otherwise unnecessarily risk introduction of infection into the tympanic cavity.

Inflation may be attempted after full vasoconstriction has taken place. This can be accomplished by either Politzerization or controlled positive pressure techniques.[11,56,57] The latter methods are favored because successful inflation of the ear can be achieved with a small amount of pressure, and trauma is minimal. The usual procedure is to apply the air pressure through an olive nasal tip held snugly in the nostril of the affected side, at the same time occluding the opposite nostril with the fingers. The air current is then turned on and the patient is requested to repeat "kay" or "koo-ook," thus occluding the nasopharyngeal space intermittently while air is forced into the Eustachian tube.[24,57]

Catheterization of the Eustachian tube is not favored, since it is a delicate procedure which may result in more damage than can be compensated for by successful inflation. Even in experienced hands, a certain amount of trauma or at least reflex hyperemia may be produced in and about the tubal orifice.

Myringotomy or tympanic paracentesis with a hypodermic needle[6] should be reserved for cases which do not respond to the usual methods of vasoconstriction and inflation. Aspiration of the fluid from the middle ear prevents its subsequent organization into adhesions, which may result in permanent hearing impairment.

Aural pain is usually mitigated by mild analgesics, such as the salicylates or codeine. The instillation of warm, soothing oil or of tepid water into the external canal may give considerable relief, but dry heat is preferable. Heat probably induces vascular engorgement of the middle-ear structures, and, since such engorgement is space-filling, it may help to neutralize to some extent the effects of the vacuum existent in the pneumatic spaces.

For the delayed type of aerotitis media attributed to absorption of oxygen from the tympanic cavity, postflight inflation with helium has been used successfully as an adjuvant measure.[44,60]

Correction of Contributing Etiologic Factors.—This feature of management resolves itself into a careful investigation and correction of all nasopharyngeal and dental pathologic processes.

If enlarged tonsils, adenoids, or posterior turbinal tips are producing obstruction, they should be removed surgically, but only by the most careful and least traumatizing of techniques. If correction of a deviated nasal septum will improve an existing associated infectious situation, submucous resection should be recommended. Allergic conditions should be combated vigorously. Islands of lymphoid tissue in and about the Eustachian orifice are best treated by the use of radium or radon nasopharyngeal applicators. The technique of nasopharyngeal irradiation has been adequately described elsewhere.[7,31,33,61] Because of the small but important role played by malocclusion or other dental ab-

normalities in the causation of aerotitis, appropriate correction of these conditions should be instituted.

Summary

Aerotitis media is a syndrome caused by obstruction of the auditory tube and its consequent failure to properly ventilate the tympanic cavity during rapid changes in atmospheric pressure. It characteristically occurs in flight, usually during quick descent, but it may also take place during compression in those working under increased air pressure, as in caissons and submarines. It is noninfectious in nature.

The clinical picture is that of aural pain, a mild conductive deafness usually of the low-tone type, fullness in the affected ear, autophony, tinnitus, and, occasionally, vertigo. The diagnosis is usually readily made from the history, otoscopy, and nasopharyngoscopy.

The etiologic predisposing and contributing factors are reviewed in detail. Ignorance of and ineptitude in the performance of simple maneuvers to ventilate the ears during flight are significant features in the inadvertent inception of aerotitis.

The management of aerotitis media is presented in its three main divisions of prevention, active treatment, and the correction of contributing etiologic factors. Here, again, emphasis is made that those who employ aircraft frequently as a method of transportation should acquaint themselves with, or be indoctrinated in, the theory and technique of middle-ear ventilation in order to more effectively reduce the incidence of aerotitis media.

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Histopathology of Stapes Ankylosis

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Introduction

More basic knowledge of stapes fixation is vital if we are to improve the techniques now used to alleviate the conduction deafness of otosclerosis. This paper will describe the ankylosed and partially fixed specimens available to me, but much more histological material is needed for a thorough understanding of the many ways that the stapes can be hampered in its movements by otosclerosis as well as by other types of disease. The recent paper by Rüedi [1] of Zurich, describing some 80 cases of otosclerosis, will help, but even this is not complete. Nowhere in the world do we have enough autopsy material, with good case histories and audiometric data. Until these are obtained we must carefully restudy the specimens and published data available.

Observations

Otosclerosis may be associated with either fibrous or bony changes in the niche of the oval window. However, the osteoporosis and osteogenesis in the labyrinthine capsule can be quite extensive and yet produce no symptomatology at all.[2-7] There are several different ways that the stapes has been found to be bound down, so that it appears, from histological observation, that the perilymph of the labyrinth might not move normally when subjected to air-borne sound. The types of stapes fixation found in our specimens are as follows:

1. Anterior fibrous adhesions growing across the promontory from the anterior border of the oval window and potentially hobbling the stapes (Fig. 1*D*). This can also come about from inflammatory processes alone, or calcification of the annular ligament, but is quite common with otosclerosis even without demonstrable bony bridges. Just how much deafness will be caused by such a lesion is always speculative. Guild and his co-workers have described cases in which the ankylosis was histologically confined to the anterior crus (as in Fig. 1*D*) where no deafness was detectable.[2-4]

2. The head of the stapes can be fixed to the promontory. This is probably, but not necessarily, a concomitant of inflammatory rather than otosclerotic disease. It can be associated with head trauma.

3. Bony bridges can occur outside the annular ligament. There is often a history of otitis media in childhood. Exostoses and adhesions can occur behind the posterior crus, as in Figure 3, where there is also considerable otosclerosis, with hyperostoses and disease at the site of predilection, anteriorly (Fig. 4).

4. Calcified concretions can occur within the annular ligament and in such a position could hobble the stapedial movements (Fig. 5). These concretions can completely bridge the annular ligament (Fig. 6) and are usually present with fibrous adhesions to the anterior crus (see Fig. 1*A*, *B*, and *C*).

5. The annular ligament can be narrowed by bony invasion. This can reduce the elasticity and scope of normal stapedial movements. This can occur either anteriorly or posteriorly to the stapes, or from the stapes itself, as in Figure 7.

Accepted for publication Dec. 21, 1956.

Dedicated to Prof. Dr. Gustav Hofer, of Graz, Austria, on the occasion of his 70th birthday.

Read before the Otosclerosis Study Group and the Committee of Conservation of Hearing of the American Academy of Ophthalmology and Otolaryngology, Chicago, Oct. 14, 1956.

From the Department of Otolaryngology, College of Physicians and Surgeons, Columbia University. Work performed under grants from the Central Bureau of Research of the American Otological Society and the New York Foundation.

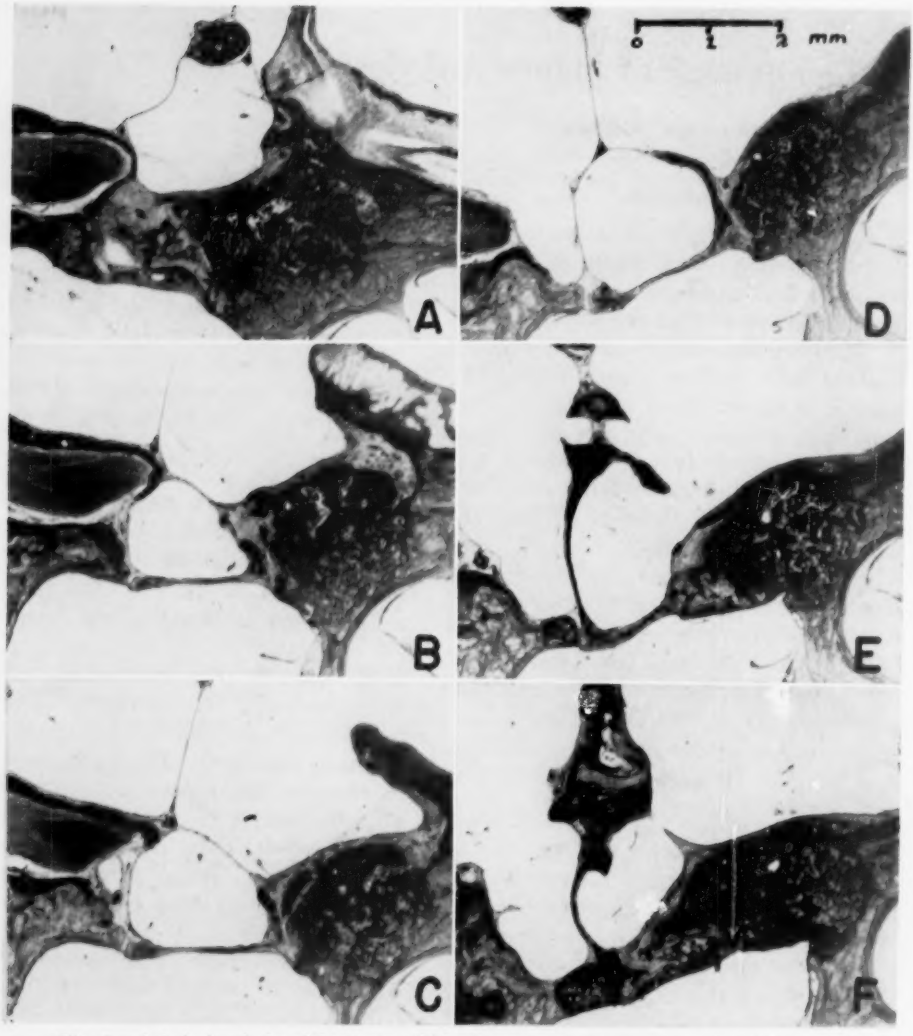

Fig. 1.—Ankylosis of the right stapes. This shows many of the types of ankylosis. The sections shown are approximately 0.5 mm. apart. *A*, section through superoanterior end of the footplate showing calcification and new bone growth in the niche in front of the anterior crus of the stapes. *B*, *C*, and *D*, fibrous and calcareous ankylosis of the anterior crus to a typical otosclerotic process at the site of predilection. *E*, displacement of posterior part of the footplate. *F*, partial ankylosis of posterior part of the footplate of the stapes and the posterior crus. (For audiogram, see Fig. 2.)

6. The annular ligament can be altered by displacement of the footplate of the stapes from its normal position (Fig. 1*E*).

7. A tiny bony bridge can halt the movement of the anterior margin (Fig. 8).

8. Single or multiple bridges of various sizes, of mixed bone and calcified spicules, can occur at any margin and apparently regardless of the positions of the main focus (Fig. 1*A* and *F* and Fig. 9.) The clinical importance of this will be discussed in detail later.

9. The focus can be in the footplate and crura and impinge on the stapes niche from within (Fig. 10). Incidentally, in such cases the size and weight of the stapes are

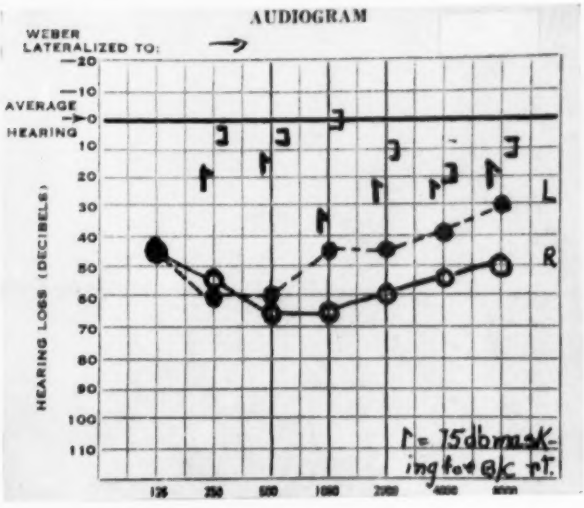

Fig. 2.—Audiogram of case seen in Figure 1.

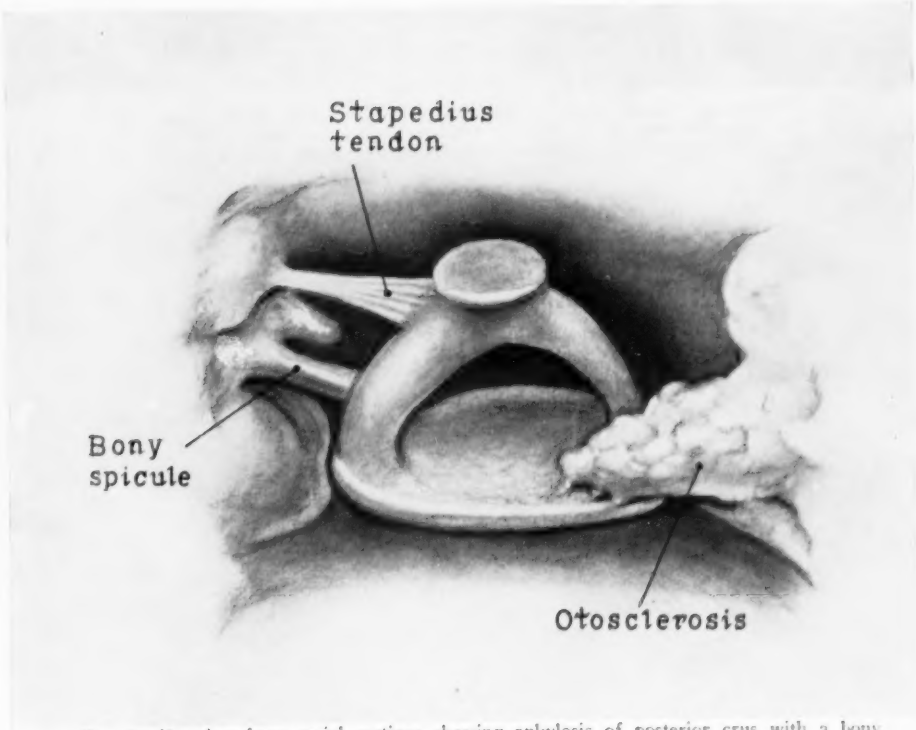

Fig. 3.—Drawing from serial sections showing ankylosis of posterior crus with a bony spicule and ankylosis of the anterior crus and footplate with hyperostotic mass of otosclerosis. (For histologic detail, see Fig. 4.)

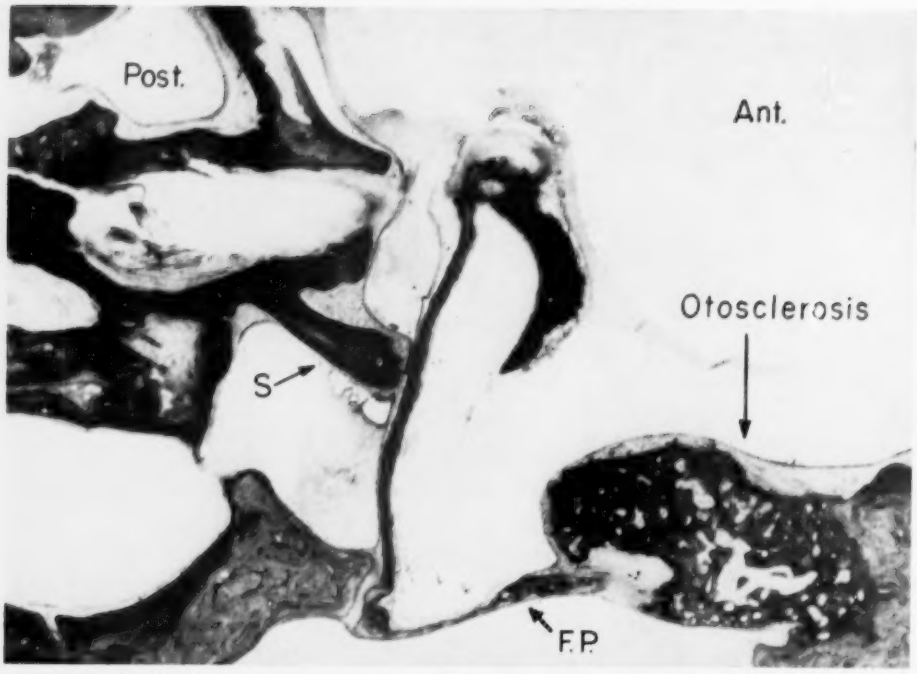

Fig. 4.—Histology of one section of case illustrated in Figure 3. Note spicule of bone (*S*) against the posterior crus and the mass of otosclerosis over the footplate (*F. P.*). This mass impinged not only on the footplate but also on the anterior crus.

Fig. 5.—Beginning ankylosis of the stapes by calcification of the annular ligament (arrow). Note also the very thin normal footplate.

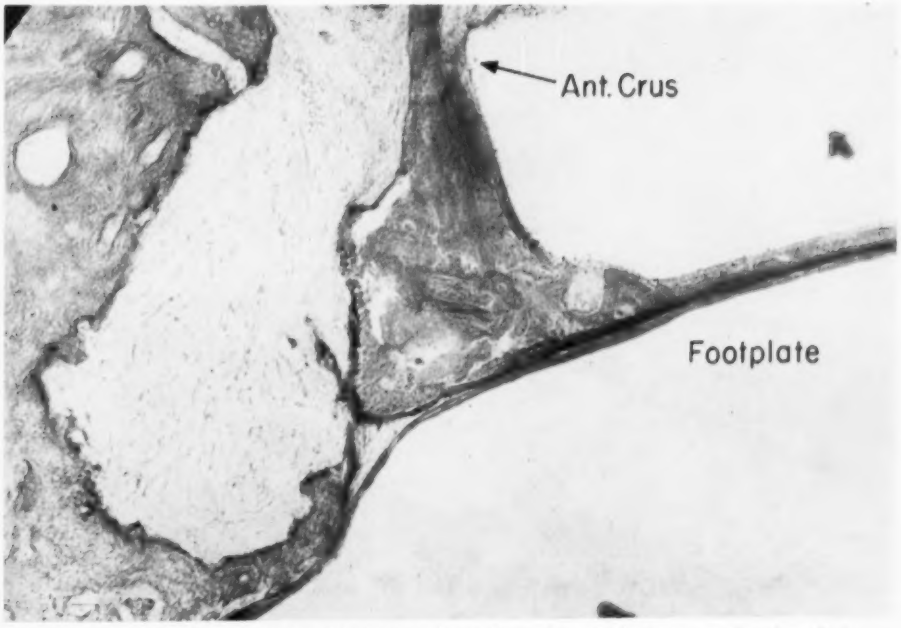

Fig. 6.—Anterior crus held with fibrous tissue from the ostotic focus at the site of the predilection and calcified-bridge ankyloses.

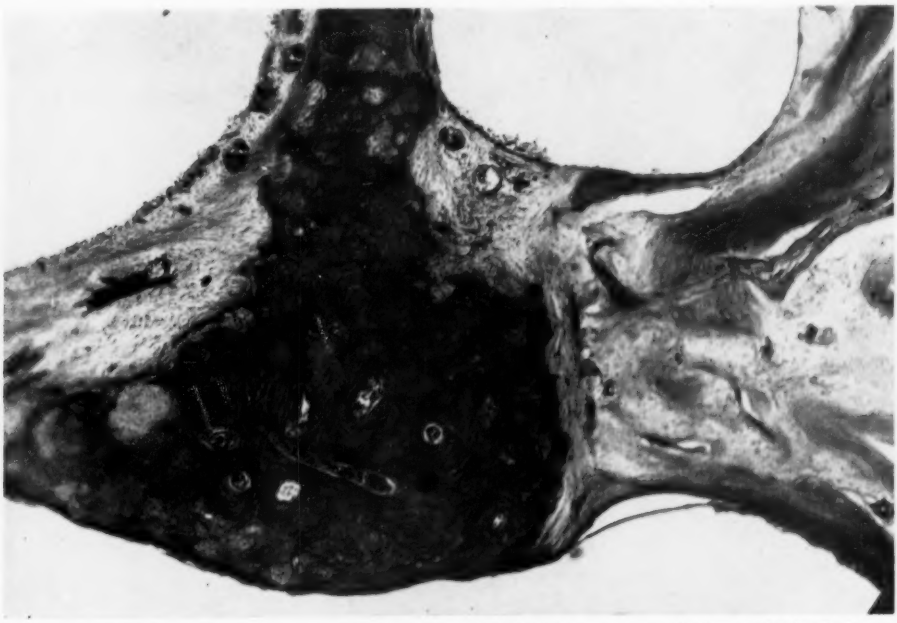

Fig. 7.—Narrowing of the annular ligament posteriorly by otosclerosis in the heel of the footplate.

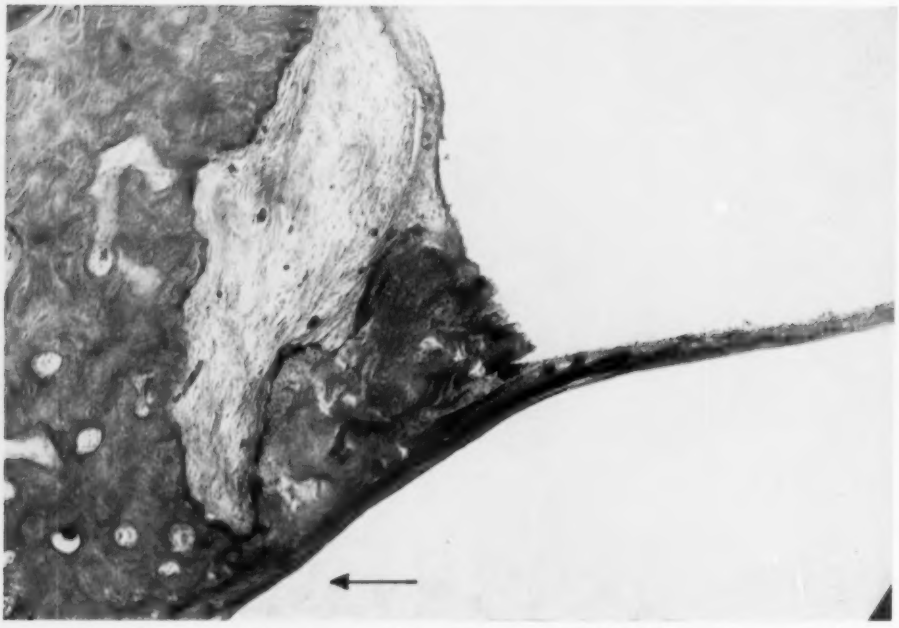

Fig. 8.—Small bony bridge from the focus at the site of predilection anteriorly (arrow).

Fig. 9.—Large bony bridge at anterosuperior margin from otosclerosis in stapes footplate.

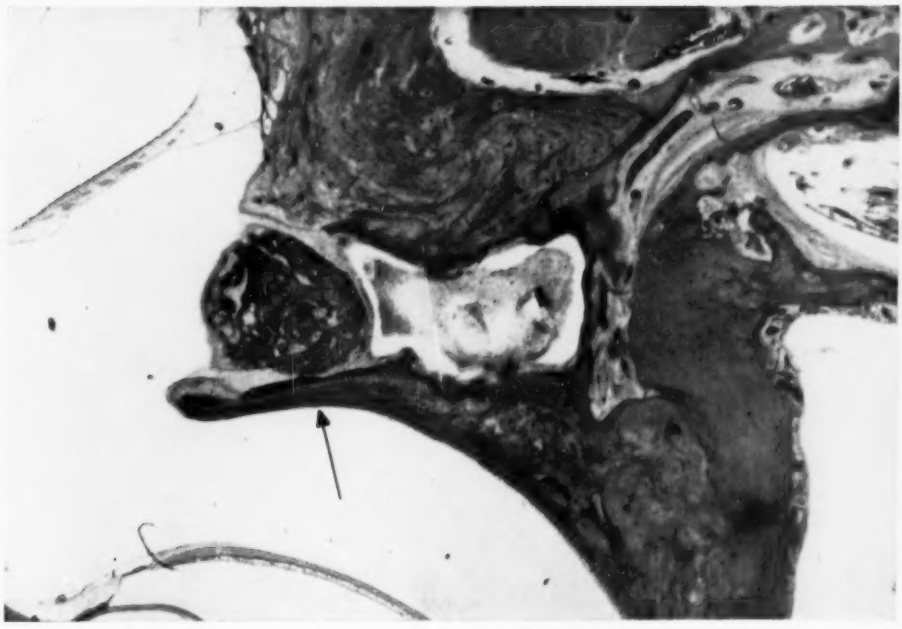

Fig. 10.—Otosclerosis in heel of stapes impinging on niche posteriorly. (See audiogram in Fig. 11.)

markedly increased and this would increase the inertia of the ossicular chain, thus, theorectically, at least, hampering the movement of perilymph. For an audiogram of such a case, see Figure 11.

10. There can be massive bony ankylosis, which may involve

a. One-third or less of the footplate
b. Half or two-thirds of the footplate
c. The entire rim of the footplate
d. All, or almost all, of the footplate (Fig. 12).

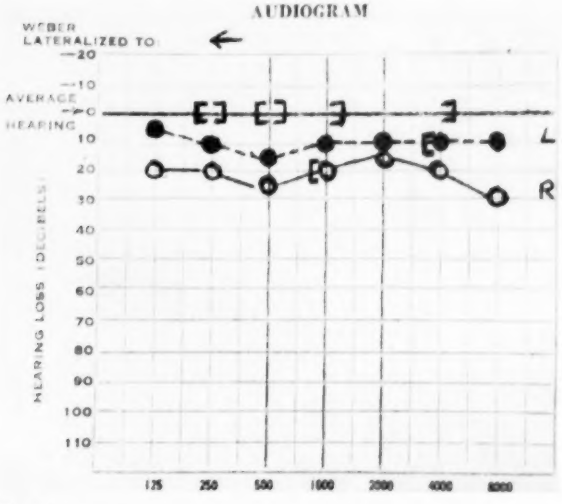

Fig. 11.—Slight hearing loss in right ear of case shown in Figure 11; normal hearing on the left.

Fig. 12.—Bony ankylosis superiorly and anteriorly in case with otosclerosis, in the footplate. There was also a large mass at the site of predilection, with ankylosis further forward.

Comment

When Rosen[8] reported his mobilization procedure, in 1953, nearly everyone was skeptical as to the probability of a permanent result from the manipulation described. "How," asked these skeptics, "is it possible to shake loose a joint ankylosed with new bone and then keep it mobile?" If we read Rosen's original papers, and those of his disciples,[11-14,16] this is still a good question, for these writers all seem to assume that Rosen's manipulation at the neck of the stapes actually loosens the whole footplate in the oval window by breaking through the disease process. Study of histological material, such as is found in the present paper, makes this appear possible in very few, if any, patients.

Figure 1 pictures a classical stapes ankylosis; the audiogram of the patient is shown in Figure 2. Such an ankylosis, or those shown in Figures 9 and 12, could hardly be broken through by the Rosen maneuver of pushing gently, but harder and harder, backward on the neck of the stapes until it "suddenly" is properly mobilized, with permanent normal, or near normal, hearing as a result.[11,12] Similarly, these cases do not look particularly amendable to the stapes-head maneuvers of Goodhill[14] or House.[16] Nor does the case in Figure 1 look like an easy one in which to lift the edge of the stapes footplate as a "manhole cover" to mobilize it, as is envisioned by some workers who practice footplate mobilization after breaking one or both crura.

Actual surgical manipulation experiments, reported elsewhere,[17] suggest that there is a much more plausible explanation for the success of the operation, when it occurs, than loosening up, or "lysis of," an ankylosed joint. I believe that what happens with all successful maneuvers is a breaking of a normal part of the footplate and, probably in many of the best cases, a fracture of one crus as well. The normal footplate is very thin endochondral bone, and it does not, as far as we know, heal by bony union.[18]

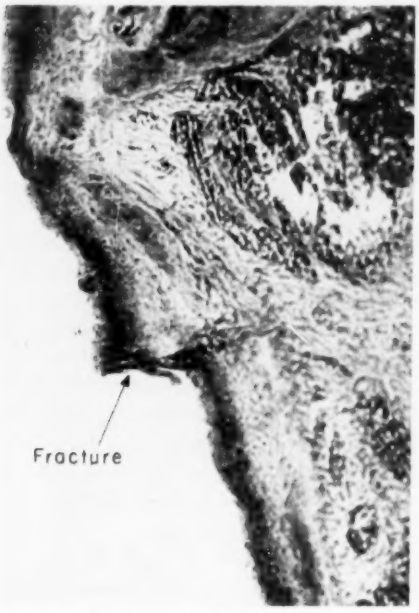

Fig. 13A.—Fracture of footplate following fenestration, with fragment displacement (arrow).

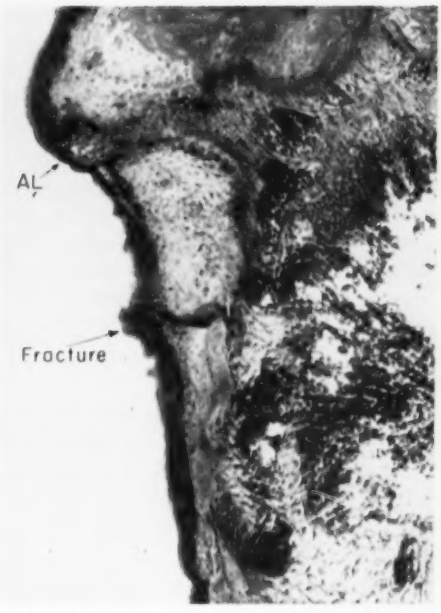

Fig. 13B.—Fracture at a point where there is little displacement. The break was a little over 1 mm. long and through the posterior portion of the stapes, which was not involved by otosclerosis; *AL*, annular ligament.

It is like the labyrinth bony capsule in this respect.[20] To my mind, a fracture through, or shattering of, a normal part of the footplate is the only logical explanation for the success of present-day stapes-mobilization procedures. This point of view was originally engendered by study of histological specimens, i. e., Zöllner's observation of an evulsed stapes, fractured through the posterior crus and footplate,[21] as well as the observations of Hallpike,[19] Altmann,[18] and others that the fractured footplate does not heal by bony union.

In the preparation of this paper I ran across a specimen which I believe helps to prove my point. During fenestration surgery the stapes is often mobilized inadvertently. In addition to Zöllner's observations mentioned above, this was clearly brought out to me in Howard House's operating room during two fenestration operations in which we were, incidentally, trying to study the mechanisms of mobilization. We were surprised to find mobilization of one and almost complete evulsion of the stapes in the other when we looked at the stapes with an operating microscope after complete mobilization of the flap and final taking down of the posterior canal wall. Incidentally, the hearing in both these cases improved after fenestration.[22]

In our collection there is a temporal bone of a patient of Dr. Woodman's (reported elsewhere[23]) in whom a standard fenestration operation had been performed three weeks before he died of thrombotic emboli. In this case the stapes was apparently mobilized through the only normal area left in the stapes (Figures 13A and 13B). This fracture can be seen in 50 vertical sections, each about 25μ in thickness.

On the basis of these observations I elaborated an operation where one crus of the stapes is deliberately cut with a shearing motion to fracture the footplate. I believed, at first, that since otosclerosis is most commonly found in the anterior border of the oval window the ankylosis must also most frequently occur there. I therefore began

by cutting the anterior crus. Deliberate severance of a crus surprised those who wrote that the operation was a failure if "one or both crura were fractured." The latter notion can not be correct, for my colleagues Dr. Altmann and Dr. Basek as well as I have performed the operation of anterior crurotomy many times with a percentage of cases with socially adequate hearing much better than our average with the original Rosen maneuver. I know of other men who have tried deliberate anterior crurotomy, with success.[23]

On the surface the above might seem to be all there is to be said on the subject, but I regret to say that this is not true. I was much disturbed when I began to get very good improvement of hearing in cases where both crura had been removed and then to read Dr. Rosen's paper on mobilization of the footplate[24] and learn that he obtained many audiograms with nearly normal hearing after fracture of both crura. This seems to undermine all our previous observations and theories in regard to the importance of the ossicles for hearing. It became clear to me, in Montreal,[16] that Rosen's percentage of good results with stapes-neck manipulation and the results of others with stapes-head, or transincudal, manipulation were generally as good and often better than mine with my anterior crurotomy with footplate fracture. I was forced to consider the possibility that all our maneuvers primarily fracture part of the footplate and that perhaps ossicular continuity is not as often attained as we have been led to believe. Meanwhile, it was discovered that there was a great deal of intrinsic elasticity in the crura of the stapes and footplate.[25] Then there was the possibility that, although the anterior border of the oval window is the commonest site for otosclerosis, the ankylosis itself may not involve the anterior crus sufficiently to cause any deafness.

With further study of histological material my former opinion that as a rule only the anterior part of the footplate and the anterior crus are involved in ankylosis with otosclerosis[17] was found to be not quite correct.

To be sure, the otosclerotic process itself is statistically most commonly present in the anterior border of the oval window and there are very often fibrous connections there.[2,7] However, the present study reveals that the bony ankylosis can be near the posterior margin of the oval window, even when a large mass of otosclerotic bone is present in the anterior border of the oval window (Fig. 1). This complicates matters, and we must therefore study every case individually on the operating table. The number of cases in this study are statistically small, but this does not contradict the observation that too often the crucial deafening bony, or calcified, ankylosis may not involve the anterior crus.

The problem now is to find a way to achieve footplate fracture oftener, without danger to the patient. If current theories as to the role of the ossicles for the hearing of weak sounds are correct, we must also find a way to keep at least one crus of the stapes intact and attached to a mobile fragment of the footplate. Ideally, we should find a way to ascertain the site of the ankylosis in the living patient before we start mobilizing. Thus, we may find a technique to increase the percentage of improved cases in this type of surgery and also find a way to increase the percentage of patients with no hearing loss, whatsoever, after surgery. Meanwhile, we might find out why it is that sometimes the hearing regresses after initially successful surgery.

I do not believe that these things can be done without more knowledge of the disease processes involved in otosclerosis. We must remove more temporal bones and study them histologically, and we must have audiograms on the patients we subsequently examine on the postmortem table. We must have material on all kinds of ankylosis. We must have valid statistics on the type and locations of the fixation of the stapes. I will have accomplished the purpose of this communication if I have impressed on the reader

the meagerness of our present knowledge and thus fired him with enthusiasm to help those who can process histological material to amass an adequate amount of data to establish proper techniques for alleviating deafness from stapes ankylosis. The methods for removal of the temporal bones have been well documented by Guild [26] and Kelemen.[27] We must have concerted action, at once, on the histopathological front. If we do not do something about our lack of knowledge the hearing in too many ears throughout the world will be nonsalvageable because of our present uninformed, and often blind, methods of attacking the stapes.

We can not advance in this micro-orthopedic surgery without the study, the knowledge, and the skill which come only from constant use of the long focal-length microscope in the operating room and the high-power microscope in the laboratory.

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The Larynx in Leprosy

C. E. MUÑOZ MacCORMICK, M.D., Santurce, P. R.

Leprosy, the tragically dreaded, disfiguring, and mutilating disease, one of the oldest afflictions exclusively of mankind, is a contagious wasting constitutional disorder caused by the acid-fast Mycobacterium leprae, first described by Hansen in 1874 (Fig. 1).

Both from the clinical and histopathological points of view, the manifestations of leprosy may be varied. The classification which divides the disease into three distinct types—the lepromatous (malignant or gravis), the tuberculoid (benign or mitis), and the indeterminate (undifferentiated)—is being used at our leprosarium, and we will adhere to it throughout this presentation.

Histopathology

In the lepromatous type the lesions are characterized by the presence of diffuse infiltration of the skin and nerves with vacuolated large mononuclear cells, or "lepra cells" (Figs. 2 and 3). In some of the viscera there may appear small groups of them as miliary lepromata. Bacilli are numerous within these cells, and in tissue spaces known as "globi."

In the tuberculoid type there are seen in the derma and in the nerves tubercle-like groups of epithelioid cells and rare giant cells; the bacilli of Hansen are very scanty (Figs. 4 and 5).

In the indeterminate type the changes are not specific, and consist only of slight perivascular infiltration with lymphocytes and plasma cells, in the derma. The bacilli are extremely difficult to find, or they may be absent, as is usually the case.

Transmission

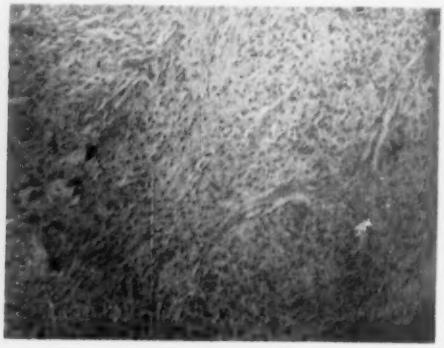
It is generally accepted that leprosy is contracted through the particular susceptibility of children, especially those under 3 years of age, and that the disease will continue indefinitely unless they are properly protected from contact with the infective leper. Except in rare cases, adults, even after prolonged exposure to the contagion, do not seem to contract the disease.

Accepted for publication Dec. 20, 1956.

State Leprosarium, Commonwealth of Puerto Rico Fundacion Investigaciones Clinicas de Puerto Rico School of Medicine, University of Puerto Rico.

Fig. 1.—Mycobacterium leprae in lepromatous leprosy.

Fig. 2.—Lepromatous leprosy; reduced ⅓ from mag. ×80.



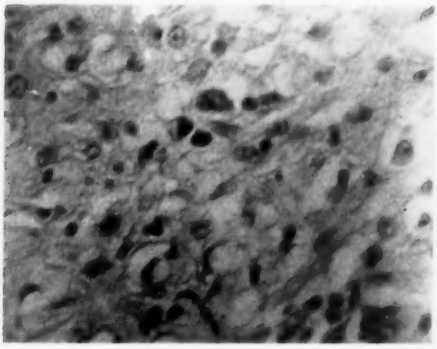


Fig. 3.—Lepromatous leprosy; reduced ¼ from mag. ×360.

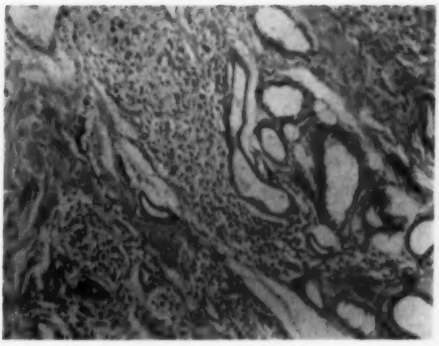


Fig. 4.—Tuberculoid leprosy; reduced ½ from mag. ×80.

Clinical Manifestations

General.—Generally speaking, it is characteristic of leprosy to present many acute phases and spontaneous recessions. In the lepromatous type these acute episodes, or so-called lepra reactions, are characterized by headaches, high fever, preceded by chills and with morning remissions and evening exacerbations), weakness, general malaise, bacteremia, cutaneous edema, swollen mucous membranes, edematous eyelids, photophobia and lacrimation, and a rash of small maculae to giant urticaria over the face and extremities, which may, in children, at times, simulate measles (Fig. 6).

In the tuberculoid patient these reactions are characterized by exacerbation of the lesions, which become more inflamed, edematous, reddened, painful, and hypersensitive. The affected nerves are swollen and tender and, occasionally, low-grade fever may appear.

These acute reactions are of relatively short duration, although they may last for weeks and are often followed by recession of the lesions and prolonged periods of apparent quiescence. They may, however, usher in steadily progressive changes. Pain may be persistent and agonizing during these reactions.

The distinguishing features of leprosy in children, according to Elliott,[4] are swelling

Fig. 5.—Tuberculoid leprosy; reduced ⅓ from mag. ×360.

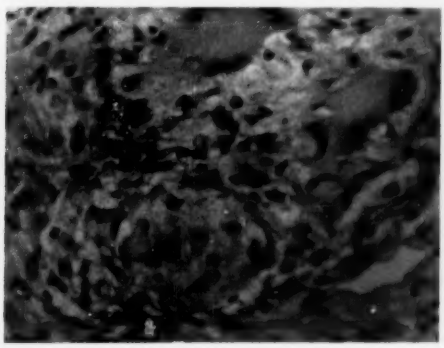


Fig. 6.—Lepromatous leprosy; lesions simulate giant urticaria.

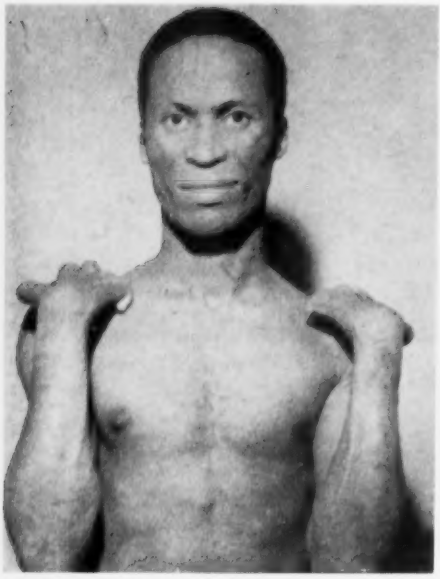


Fig. 7.—Tuberculoid leprosy: plaques and gyrate borders of former flat maculae.

Fig. 8.—Tuberculoid leprosy: swelling of the great auricular nerve.

and tenderness about the tip of the nose and edema and infiltration about the alar cartilages. Epistaxis is a common symptom, and examination of the nose will reveal a granulomatous lesion on the septum containing the characteristic acid-fast M. leprae. Pendulous lobes with nodules on the auricle indicate that the disease has been long established. Madarosis is generally bilateral and

Fig. 9.—Indeterminate leprosy.

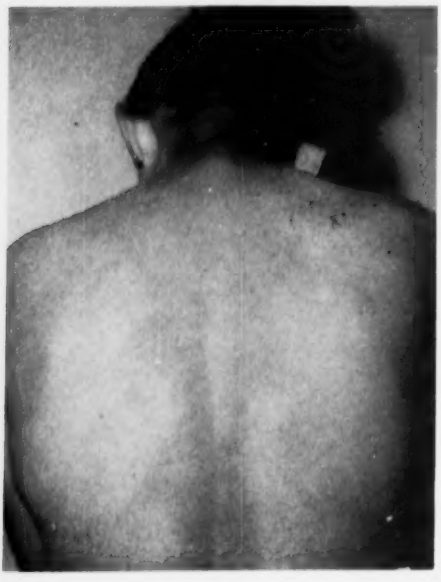


Fig. 10.—Lepromatous leprosy: lepromata on abdomen.

Fig. 11.—Lepromatous leprosy: pendulous ear lobe.

affects the outer half or third of the eyebrow. When present, it is indicative that leprosy has been clinically active for approximately five years.

Tuberculoid Leprosy.—A typical lesion is a pale, flat macula, strongly circumscribed, with diminished pigment, often having a finely granular or papular periphery and loss of sensory perceptions of varying degrees. The temperature sense may disappear first, with subsequent diminution of pain and light touch perception. These sensory changes are more noticeable toward the center of the lesion. Virtually all these lesions will show anhidrosis.

Sometimes raised edematous, sharply demarcated lesions may occur in the form of plaques, rings, or as gyrate borders of former flat maculae (Fig. 7). Their central portion is generally hypochromic and the surface is finely scaled.

The frequent localization of lesions in main nerve trunks may bring about extensive and mutilating deformities. Smooth or nodular swelling may take place, rendering the nerves easily palpable, and in certain instances, if superficially located, they may stand out quite prominently. The ulnar nerve, the peroneal, the great auricular (Fig. 8), and the supraorbital are the ones most frequently affected.

Cases of tuberculoid leprosy show high resistance to the multiplication and dissemination of the bacilli, are generally benign, tend to be stable, and give a positive lepromin reaction. The organism is not frequently found in the lesions or in nasal smears, except in reactional cases, and there is a strong tendency to spontaneous regression in the absence of repeated reactions. They are usually noninfectious.

Indeterminate Leprosy.—Sensory disturbances are rather constant but of varying degrees. The skin lesions may be few or even occur singly; they are usually macular—either hypochromic, erythematohypochromic, or erythematous (Fig. 9). These cases tend to be unstable, with a variable course as to persistence, regression, progression, or transformation into one of the "polar" types. They may give a negative or moderately positive lepromin reaction, and M. leprae is not found as a rule in the lesion. They are usually noninfectious.

Lepromatous Leprosy.—This is the type which concerns the laryngologist most because it presents lepromatous lesions not only in the skin but also in the mucous membranes of the nose, pharynx, and larynx. It bears a graver prognosis and is a more malignant type of the disease. It is the most highly contagious form, and the M. leprae is abundant in the lesions and nasal secretions. Reaction to lepromin is negative. There is a minimal resistance to the existence, multiplication, and dissemination of the bacilli.

There is usually a nodular thickening of various areas of the skin, although at times a diffuse induration may take place. The lesions may develop anywhere (Fig. 10) but appear most commonly on the face (Fig. 11), especially affecting the ear lobes (Fig. 12), the forehead (Fig. 13), the eyebrows, the nose, and the malar prominences. The skin over the elbows and knees (Fig. 14) is also frequently involved. The lepromas are darker than the surrounding skin.

The mucous membranes are early involved in this type of leprosy, as happens with the nose (Fig. 15), where a granuloma may form on the anterior portion of the septum

Fig. 12.—Lepromatous leprosy: appearance of external ear during acute lepra reaction.

Fig. 13.—Lepromatous leprosy: lesions on the forehead and eyebrows.

or ulceration may take place (Fig. 16), eventually causing total destruction of the cartilaginous septum and sinking of the tip. This, aggravated by cicatricial contraction at the site of lesion on the alae, cicatricial stenosis of the nostrils, and nodular deformities of the nasal lobule, gives rise to a hideous-looking nose, which, together with the enlarged nodular ears and nodular face, changes the facial expression of the person into the so-called "facies leontina" of leprosy (Fig. 17).

The lepromata may break down and ulcerate, or resorption may take place. Permanent changes, in proportion to the sever-

Fig. 14.—Lepromatous leprosy: lepromata of the knee.

Fig. 15.—Lepromatous leprosy: leprous granuloma showing on right nasal vestibule.

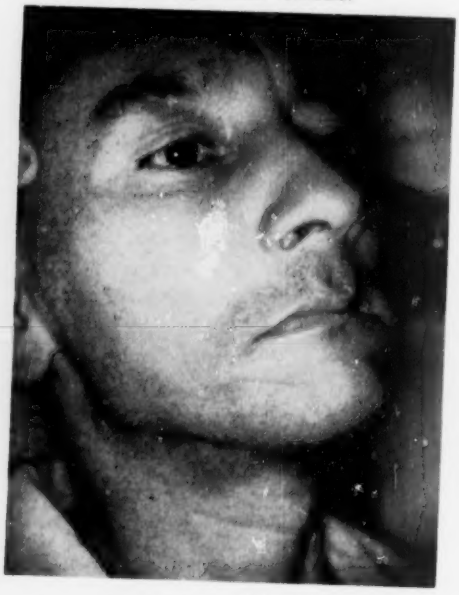


Fig. 16.—Lepromatous leprosy: large perforation of cartilaginous septum.

Fig. 17.—Lepromatous leprosy: extensive scarring and deformity and skinking of the nasal tip.

ity of the process, will occur in the form of scars, deformities, or mutilations.

Nerve trunks may be the site of lepromatous changes, with clinical signs indistinguishable from those in other types of leprosy. Destruction of the eyes, with resulting blindness, is not unusual in advanced cases.

Fig. 18.—Lepromatous leprosy: case with extensive laryngeal lesions.

The Larynx

The general incidence of leprosy in Puerto Rico has not been thoroughly investigated, but it is estimated to be about 20 per 100,000 of the population, or a total of approximately 450 cases for the whole island (Estella [7]).

Fig. 19.—The patient shown in Figure 18, demonstrating extensive pharyngeal scarring and deformity of soft palate.

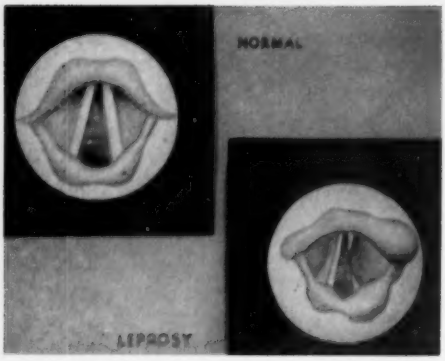


Fig. 20.—Lepromatous leprosy: artist's interpretation of laryngeal lesions in the case shown in Figures 18 and 19 (Dobal).

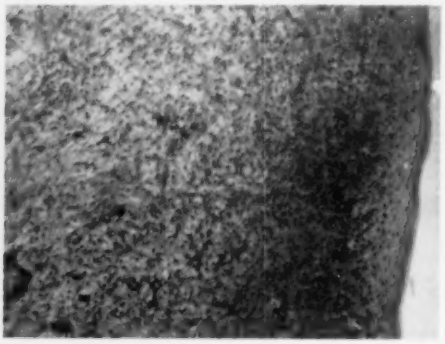


Fig. 21.—Lepromatous leprosy: biopsy specimen taken from lesion on aryepiglottic fold (shown in previous figure); reduced ⅓ from mag. × 80.

In all the 87 patients now hospitalized at our leprosarium we conducted careful indirect laryngoscopic examinations. Direct laryngoscopies were performed only in those that showed lesions of interest to the endoscopist. Rhinoscopic examinations were carried out routinely.

Though disheartening to me from a purely investigative angle, it has been a source of great personal satisfaction to find that under proper hygienic and dietetic control, and with the use of the therapeutic armamentarium now available, the extensive active lesions of the larynx which I expected to encounter are no longer seen and only one case of lepromatous leprosy (Figs. 18 and 19) has been found during the past three years that showed fairly extensive involvement of the epiglottis, aryepiglottic folds, arytenoids, and ventricular bands (Fig. 20). A biopsy specimen from a leproma in the left fold was taken (Figs. 21 and 22). The rest of the patients showed only healed lesions, mostly limited to the epiglottis.

The patients were classified as follows:

Lepromatous	65
Tuberculoid	12
Indeterminate	3
Burned-out	5

Of the 65 lepromatous patients, 46 were males and 19 females, out of which 5 males

Fig. 22.—Lepromatous leprosy: high-power view of lesion shown in Figure 21.

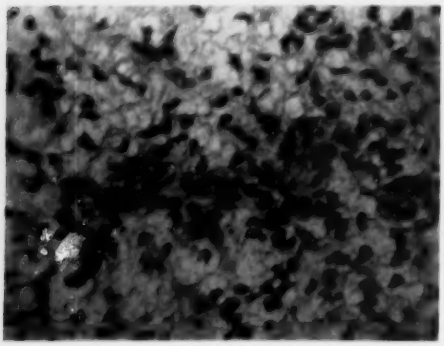


Fig. 23.—Lesions of this patient mutated from the lepromatous to the tuberculoid type. Laryngeal lesions are shown.

TABLE 1.—*Laryngeal Lesions in a Total of Eighty-Seven Cases Studied*

	Lepromatous			Tuberculoid			Indeterminate			Burned-Out		
	M*	F	T	M	F	T	M	F	T	M	F	T
No. of patients	46	19	65	9	3	12	5	0	5	3	2	5
History of hoarseness	5	2	7	2	0	2	0	0	0	0	0	0
Lesions limited to epiglottis	4	1	5	1	1	2	0	0	0	0	1	1
Lesions extending also to other laryngeal structures	9	2	11	0	0	0	0	0	0	0	0	0
Total No. with laryngeal lesions			16			2†						1

* The meanings of the abbreviations are as follows: M, males; F, females; T, total number.
† The lesions in these two cases mutated from the lepromatous to the tuberculoid type under treatment. Healed laryngeal lesions now seen probably occurred as part of the lepromatous manifestations.

and 2 females gave a history of hoarseness of more than a few months' duration and occurring sometime during the course of their illness. Lesions were limited to the epiglottis in four males and one female, and involved the epiglottis and aryepiglottic folds or extended beyond these areas in nine males and two females. Thus 16, or approximately 24%, of the lepromatous cases showed some degree of laryngeal involvement.

In the tuberculoid group of 12 patients, 9 were males and 3 females. A history of hoarseness was obtained in two males only, and scars limited to the epiglottis were encountered in one male and one female, thus giving a total of two. This figure is statistically of no consequence because the lesions in both these patients mutated from the lepromatous to the tuberculoid type under treatment (Fig. 23), and, although definitely pertaining now to the latter classification, the laryngeal lesions probably occurred as part of the lepromatous manifestations.

There were only five cases under the indeterminate group, all males and none of them exhibiting any laryngeal changes. One of them, a young boy, is now being reclassified to prelepromatous, as induration with appearance of active lesions on the face has taken place (Fig. 24).

A burned-out case is an old lepromatous one that never received treatment. After repeated acute episodes for years, the active disease fades away and the patient is left free from organisms and is apparently cured but with extensive mutilations and horrid deformities, and is crippled and not infrequently blind (Figs. 25–27).

In the "burned-out" group there were five, three being males and two females, and although all presented atrophic laryngeal structures with a thin, slightly grayish, pale mucous membrane covered by a thin, transparent exudate, only one female patient

Fig. 24.—Indeterminate type of leprosy undergoing prelepromatous changes. Note lesion on left malar region.

Fig. 25.—Burned-out case showing extensive mutilations of hands and feet.

Fig. 26.—Burned-out case showing blindness and extensive mutilation.

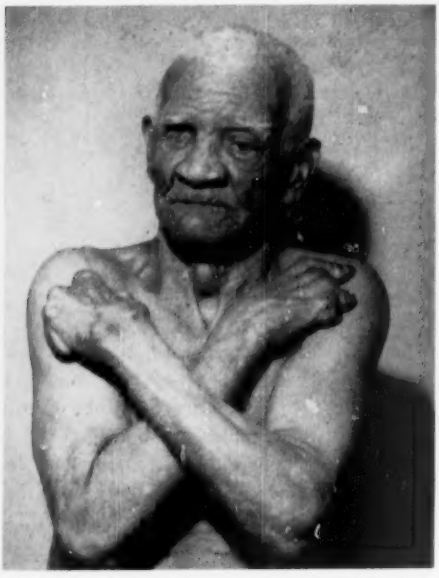


Fig. 27.—Case of advanced leprosy, with blindness and mutilations of both hands.

showed healed, more extensive, laryngeal involvement.

The most frequent lesion of the larynx in leprosy consists of lepromata of the epiglottis, with subsequent destruction, scarring, and thickening. The epiglottis may be shrunken and incurved. The nodules may extend to the aryepiglottic folds and arytenoids in some of these cases and may also involve the vocal cords. The folds may become contracted, pulling the epiglottis toward the arytenoids; and infiltration of the thyroarytenoideus and cricoarytenoideus muscles may interfere with the normal mobility of the cords.

In passing, I should like to call attention to the fairly constant findings of nasal pathology in all cases of leprosy, as shown in Table 2. Out of the 87 patients, 48 showed ulcerations of the mucosa of the septum to a varying degree, 14 had partial destruction of the cartilaginous septum with large perforations, and in 17 it was totally destroyed. Thus, 90.8% of all cases had positive findings in the septum. Only eight cases did not show gross pathologic changes in the nose. These belong to the indeterminate and early tuberculoid groups. Among the former there are three brothers, aged 9, 11, and 13, respectively, whose father died with leprosy a few years ago. One of these boys, whose lesions underwent mutation to the lepromatous type, as already shown, has responded very favorably to intense therapy.

TABLE 2.—*Pathology of the Nasal Septum in Cases of Leprosy*

	No.	%
Total no. of cases examined	87	
No gross pathology	8	9.2
Ulceration of mucosa (varying degrees)	48	55.2
Partial destruction of cartilage with perforations	14	16.1
Total destruction of cartilage	17	19.5
Total no. of cases with evident nasal pathology	79	90.8

Diagnosis

An important factor in making the diagnosis is to be leprosy-conscious and to thoroughly search, when suspicion-arousing laryngeal signs or symptoms are present, for nasal, skin, and nerve lesions. This requires a careful examination of the entire body, and scrapings of the anterior portion of the septum nasi for preparation of smears for bacteriological examination.

TABLE 3.—*Differential Diagnosis of Laryngeal Lesions*

	Tuberculosis	Syphilis	Leprosy
Development of symptoms	Gradual onset and slow increase	Rapid onset	Gradual; aggravated by repeated reactions
Hoarseness	Voice weak and hollow, then hoarse, dysphonia and aphonia	Voice hoarse, rough; no dysphonia	Typical husky toneless voice
Location of lesions	Posterior commissure is affected first; arytenoids, folds, cords, and laryngeal surface of epiglottis usually later	Usually affects anterior structures	Epiglottis (either surface) first; then folds, arytenoids, and cords
Lateralization	Usually bilateral	Usually unilateral	Widespread
Cough and sputum	Early, marked, and copious sputum	Only with ulceration; foul	Cough, if present, is dry, metallic
Nature of infiltration and ulceration	Mucous membranes are hyperemic. Ulcerate early, with rather superficial destruction of tissues. Multiple, nibbled, thin edges.	Mucous membranes are intensely hyperemic. Ulcerate quickly, with deeper destruction of tissues. Sharply defined single ulcer. Marked surrounding congestion.	Mucous membranes are pale and gray. Intensely nodular and may not break down, but if it does, the epiglottis may be destroyed.
Pain	Early and severe	Little pain and late with perichondritis	No pain
Cicatrization	Scarring with superficial distortion	Deep destruction more than distortion	Tends to heal with scars, causing distortion. Adjoining area with nodular infiltration.
Biopsy	Tubercle	Gumma	Leproma

Punch biopsies have always been feared because of the possibility of exciting intractable ulcerations which might not otherwise occur.

With the therapeutic armamentarium at our disposal, ulceration has not taken place at our sites of biopsy even when biopsy specimens were taken from lesions in the mucous membrane.

Syphilitic lesions may resemble leprosy to such an extent that the latter is frequently mistaken for the former (Table 3). To make things worse, over 45% of lepromatous patients have a positive serology, the intensity of the test result increasing with progress of the disease and diminishing with recession. However, demonstration of the M. leprae in smears or biopsy, where it is usually abundant in this form of the disease, and the characteristic sensory disturbances indicate leprosy.

Tuberculosis may also resemble the tuberculoid type of leprosy. Here, again, sensory disturbances point to leprosy, and a thorough examination of the cutaneous lesions will help to establish the diagnosis. The histamine test may prove very helpful, and in extreme cases we may resort to a study of the cultural characteristics of the bacilli, as M. leprae will not grow in any culture medium.

In the appearance of the larynx all three conditions may resemble each other at some stage of the disease.

Tuberculosis almost always involves the posterior part of the larynx first and as a rule is bilateral and painful; the mucous membrane looks hyperemic and has a tendency to ulcerate. The most frequent site of the lesion is the posterior commissure; the arytenoids, folds, and epiglottis are involved later.

Leprosy involves the epiglottis first and the folds, arytenoids, and cords later. The anterior and the posterior surface of the epiglottis are affected alike, and it is characteristically almost painless. In the earlier stages the mucous membrane is pale and gray; when seen later the lesions are widespread, involving several parts.

Syphilis is usually unilateral and almost always involves the anterior structures. It ulcerates quickly, the ulcer being sharply defined with clear-cut edges and surrounded by smooth and highly congested areas.

The larynx, whenever involved in leprosy, is definitely nodular (Fig. 28). When ulceration occurs, aided by secondary infection, the epiglottis may be destroyed. The destruction of tissue in laryngeal leprosy, however, is not as great as that seen in tuberculosis or syphilis with the same amount of nodular involvement. Leprosy tends to heal, and scars cause distortions in one area, while the adjoining area is actively infiltrated with nodules. As pointed out by Pinkerton, a leprous larynx may be intensely nodular and infiltrated and not

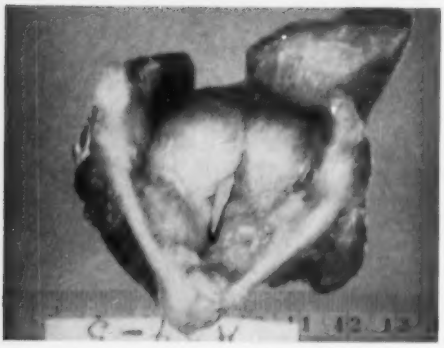


Fig. 28.—Leprosy of the larynx (courtesy of the Armed Forces Institute of Pathology, Washington, D. C., A54-5).

break down, while in tuberculosis and syphilis no such extensive nodular infiltration takes place without early deep ulceration and breaking down.

Treatment

The use of the sulfone derivatives in the treatment of leprosy was quite revolutionary during recent years. Among them there are glucosulfone (Promin), sulfoxone (Diasone; Diamidin), thiazolsulfone (Promizole), and Sulphetrone.* They can all produce a variety of toxic manifestations with selectivity for the hematopoietic system and occasionally effecting changes in personality.

The first beneficial effects of sulfone therapy are observed in lesions of the mucous membranes, especially of the nose, mouth, and larynx, to the extent that the tracheotomies, which were of not infrequent occurrence in previous days, have entirely passed out of the picture during the last few years. Next, it causes the nodular lesions to subside and, finally, the bacilli to disappear from all lesions (compare Figs. 13 and 29).

Among the antibiotics, streptomycin sulfate seems to be having beneficial effect in the treatment of leprosy, and Estella believes that it is one of the best and most efficacious drugs for treating the leprous reaction in lepromatous patients.

The thiosemicarbazones (T. B. 1.) have a definite effect on the disease, but any conclusions drawn at this time would be quite

* Sulphetrone is tetrasodium 4,4'-bis(γ-phenylpropylamino)-diphenylsulfone α,γ,α',γ'-tetrasulfonate.

Fig. 29.—Lepromatous leprosy: the patient shown in Figure 13, after treatment.

Fig. 30.—Epithelioma of the cheek in a case of lepromatous leprosy.

premature. They are used in cases where the sulfone derivatives are contraindicated.

Isonicotinic acid hydrazide is being used experimentally at the Insular Leprosarium of Puerto Rico, and it seems, so far, to be a promising drug. Besides having some specific action against the lesions, it causes the patients to become optimistic to euphoric and gain in weight.

Intravenous corticotropin (ACTH) has also been used at this institution in the treatment of the lepra reaction in lepromatous patients, with excellent results, especially when ocular complications are present.

In general, the treatment of leprosy is long-drawn, perhaps tedious, and subject to frequent complications. It should be in the hands of a well-trained specialist who knows the disease well, and it requires on the part of both the patient and the physician a great deal of patience, hope, faith, and—above all—courage.

Summary

An attempt is made to briefly discuss the clinical and pathological aspects of the three types of leprosy, namely, the lepromatous (gravis), the tuberculoid (mitis), and the indeterminate type.

A study of 87 patients hospitalized at the State Leprosarium is reported. Evidence of laryngeal involvement was observed in 24% of the lepromatous cases. In most of them the laryngeal lesions were slight and healed. The epiglottis is the most constant site of laryngeal leprosy, the aryepiglottic folds, arytenoids, and cords being involved later.

Attention is called to the high percentage of cases showing gross nasal pathology (90.8%).

A few remarks are made in reference to the modern trends of treatment at our leprosarium.

Park Terrace 71.

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Observations on the Experimental Use of Radioactive Isotopes Within the Larynx of the Dog

Notes on the Submucosal Compartments of the Human Larynx

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Studies on the local spread of fluids injected into the larynx, carried out as a preliminary investigation to the use of radioisotopes, have revealed interesting anatomical data pertaining to the presence of isolated submucosal laryngeal compartments. These are herein reported.

Whether the use of radioisotopes will be effective in the treatment of laryngeal cancer is not known, but before it is attempted, certain basic facts should be established. These include the direction and degree of spread of fluids injected into a particular site, and the effects of locally injected radioactive isotopes on the normal structures of the larynx. A technique needs to be developed for the injection of the isotopes to assure effective distribution throughout the involved area and to avoid contamination. Determination of the length of time that the radioisotope will remain within the larynx is of particular importance, since up to now it has not been known whether such particulate solutions, when injected, remain in situ for a sufficiently long period of time to be of therapeutic value or are speedily disseminated to the regional lymph nodes throughout the body without remaining within the larynx long enough to be effective. The results of such basic studies are the subject of this presentation.

The first of these investigations consisted of attempts to ascertain the direction of flow and distribution of colloidal fluids injected submucosally into the human larynx. For this purpose, preliminary studies were made on cadaver larynges. Massive injections of 4% Direct Sky Blue dye (Wyeth Laboratories, Inc.) were made submucosally into various areas of the larynx, and its distribution was noted. The findings resulted in conclusions reported elsewhere [1] to the effect that the larynx is divided into a number of compartments isolated from one another insofar as submucosal injections are concerned. First, fluids injected into one side of the larynx did not cross to the opposite side regardless of whether the site of injection was supraglottic, glottic, or subglottic. This conforms to the pattern of laryngeal edema as described by Hajek.[2] Secondly, on any one side limits of spread to specific compartments could be recognized. These specific compartments included the subglottic area from the lower limit of the cricoid cartilage to the lower level of the true vocal cord (Fig. 1), the margin of the true vocal cord itself (Fig. 2), the ventricle of the larynx (Fig. 3), and the supraglottic area including the aryepiglottic fold (Figs. 4A and 4B). It was particularly noted that the fluids injected at the level of the false vocal cord and above did not enter the cavity of the ventricle of the larynx. It was also noted that when the ventricle was

Accepted for publication Dec. 26, 1956.

Read before the Sixth International Congress of Otolaryngology, Washington, D. C., May 5-10, 1957.

This work has been supported by grants-in-aid C-2203 and CS-9241 from the National Cancer Institute, United States Public Health Service.

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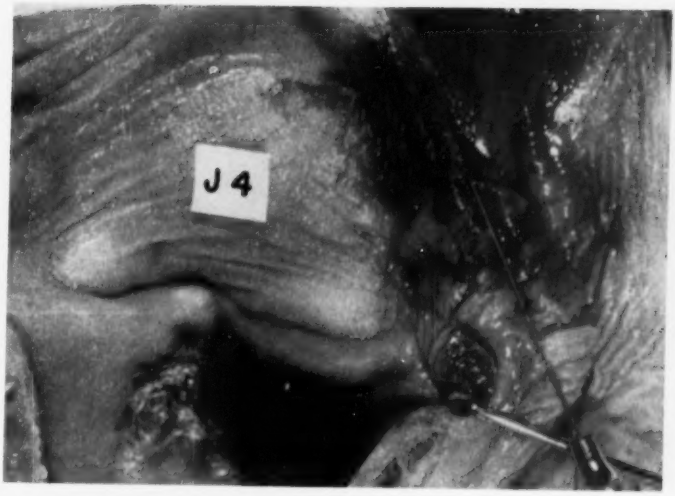


Fig. 1.—Human larynx: Injection into subglottic area. Note limitation of spread of fluids injected submucosally, demonstrating unilateral distribution and sharply defined limit of spread superiorly at lower level of the true vocal cord.

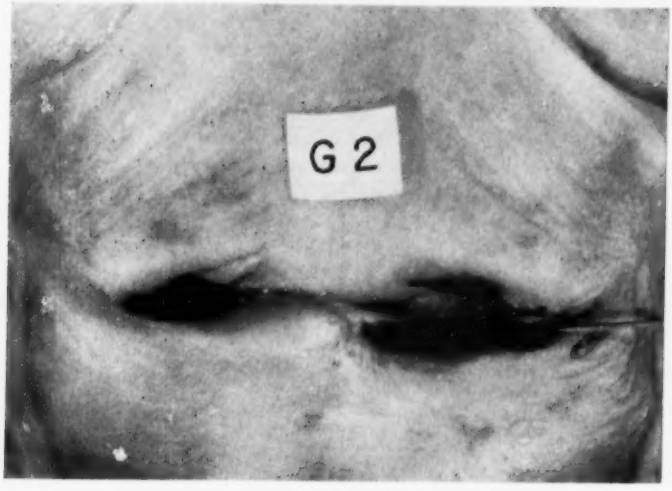


Fig. 2.—Injection, margin of vocal cord: Localization of injected dye to free margin of the vocal cord, with sharp demarcation at lower limit and failure to spread to subglottic area.

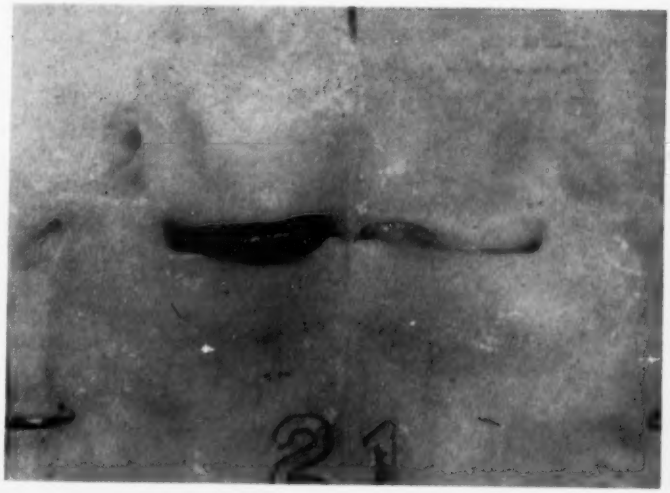


Fig. 3.—Injection, ventricle of the larynx: This demonstrates absence of spread beyond confines of the ventricle despite extreme distention of the latter. (Note the injection of a single lymphatic which extends across the midline to the opposite ventricle.)

Fig. 4A.—Supraglottic injection: This demonstrates that at higher levels spread of injected dye takes place only as far as the margin of the cartilage of the epiglottis and below the sharply defined limit of spread to the midline. Note the sharp line of demarcation inferiorly at the margin of the false vocal cord.

Fig. 4B.—Supraglottic injection: This demonstrates the absence of dye from the inferior surface of the false vocal cord and the laryngeal ventricle when dye is forcibly injected in the supraglottic space immediately above.

injected a single lymphatic channel was observed to surround the ventricle, converging anteriorly and passing as a single channel across the midline to the opposite side, where it again bifurcated to surround the opposite ventricle. This is illustrated in Figure 3, but is much more discernible on colored slides. It is the only route noted of crossover from one side to the other.

In order to confirm these findings upon the living human larynx, the larynges of patients requiring laryngectomy were injected submucosally with dye (4% Direct Sky Blue) through a direct laryngoscope several hours preceding surgery, and the extent of the spread of the dye was noted at operation. Observations were made after four hours, and it was demonstrated that fluid injected into one lateral half of the larynx remained confined to that one side, eventually spreading upward over the aryepiglottic fold to the posterior aspect of the larynx. It did not, however, cross the midline by direct extension or lymphatic spread to the opposite side of the larynx. The finding was confirmed after the larynx had been surgically removed (Figs. 5A and 5B).

Since animals were to be used for the actual determination of the local effects of injected radioisotopes, as well as to observe the degree of retention over a period of time, the above experiments were repeated on the dog and the pig. Four per cent solutions of the Direct Sky Blue dye were injected submucosally, both with and without sectioning the anterior commissure of the larynx. Observations made previously on humans were confirmed. No dye was observed to pass from one side to the other, with or without an intact anterior commissure, even when the observation continued for as long as 12 days. Observations with dye could not be made for a longer period, since the presence of the dye could then no longer be detected. For longer-term studies, radioisotopes were

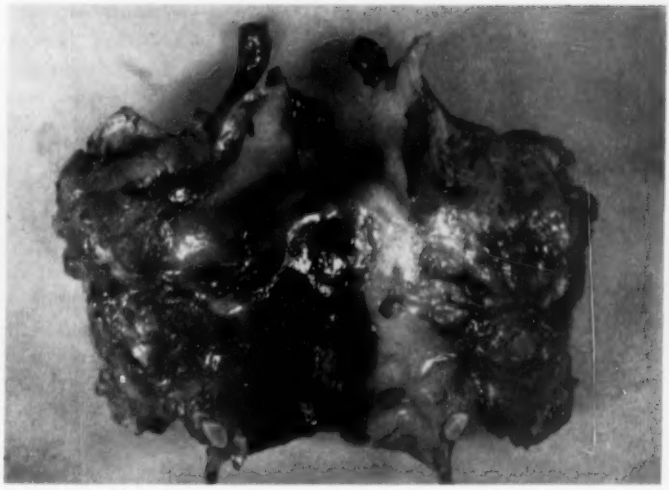


Fig. 5A.—Human larynx injected by direct laryngoscopy four hours prior to laryngectomy; Internal view with larynx split through anterior commissure. The injection was made submucosally in the intact larynx in the subglottic space of the uninvolved tissue below the middle of the right true vocal cord. About 0.5 cc. of dye was used. Note sharp limitation of spread at the midline after approximately five hours.

used, and the spread studied by the following method.

Radioactive chromic phosphate, tagged with radiochromium and radiophosphorus, was injected by a technique to be described. The material was generally distributed over the entire interior of one side of the larynx. By a specially constructed scintillation counter (Fig. 6), designed for use in animals, the larynx of the dog was scanned at intervals up to eight weeks. No crossover took place (Figs. 7A and 7B). Radioactivity was discernible soon after injection as being confined to the injected side of the larynx only. No crossover beyond the midline of injected radioactive colloidal fluids took place in the illustrated example after four weeks, and these findings have been repeated after eight weeks. There is no reason to believe that the situation is any different in humans.

Concerning the immediate fate of injected radioisotopes, it was ascertained by direct

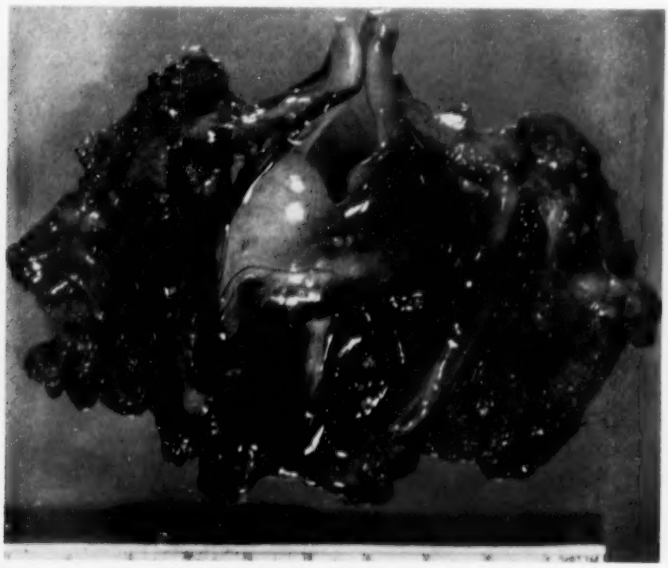


Fig. 5B.—External view of larynx in Figure 5A. Note spread to posterior surface of injected side and relative freedom from the dye of opposite side.

Fig. 6.—Scintillation counter, constructed especially for use on experimental animals.

counts of blood samples that small amounts of the injected radioisotopes appear in the blood (in a matter of minutes), but this cleared from the blood stream in a few hours.

Fig. 7A.—Scintigram: Right side widely injected with radioactive isotope. Vertical line represents midline of larynx at anterior commissure.

Within 24 hours after injection, counts taken over the larynx indicated a loss in radioactivity of approximately 25%. This represents an immediate spread from the larynx to other areas of the body, but little or no further loss of activity over the larynx was observed during the next eight weeks.

The fate of the lost 25% has not as yet been entirely determined. Part of it is accounted for by passage into the lymph nodes of the neck, but evidently the distribution did not extend into other lymph nodes, although these have not as yet been studied minutely. Apart from the 25% loss to the adjacent

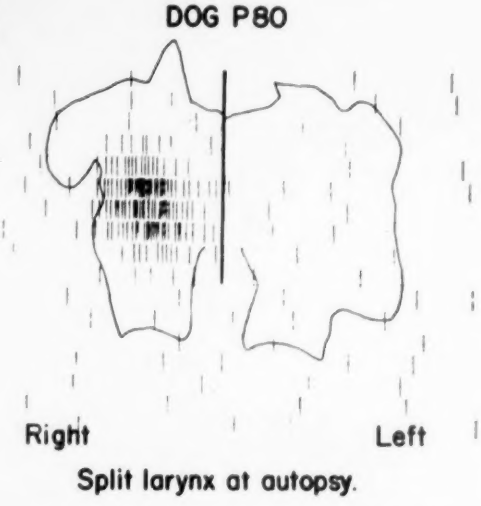


Fig. 7B.—Scintigram made 8 weeks after dog was killed. Outlined area represents tracing of larynx super-imposed upon scintigram. Note (1) absence of spread of isotope across the midline and (2) retention of radioactive material within larynx after prolonged period.

lymph nodes, an additive 15% is subsequently recovered in the liver and spleen. After eight weeks, there was, as determined by A. M. A. examination after the animal was killed, invariably a significant degree of radioactivity in one or more of the lymph nodes on the injected side. After they and the larynx were removed, no further radioactivity was found in the neck. The remainder of the structures in the neck, therefore, did not absorb or retain the radio-

active material. The immediately adjacent salivary glands at no time were radioactive.

Since it was found that ordinary injection methods were unsatisfactory, resulting in gross and quantitative inaccuracies, injections were made by means of a specially designed radioisotope injector* (Fig. 8). The apparatus is an electromechanical, leakproof injector activated by a foot switch, delivering fixed amounts of fluid through a 3 to 5 ft. section of flexible tubing into a blunt-tipped needle. The amount of fluid delivered per injection can be varied as necessary from 0.1 to 0.4 ml.

The requirements for the most effective pattern of injections were considered to have been satisfied anatomically by the study of the spread of colloidal dyes as previously described. Each compartment, as identified by these observations, has, in the final studies with radioisotopes, had one or more injections of radioisotopes placed directly into it.

It has been observed from gross examination that, when injected in this manner, the smallest amount of radioactive isotopes which we have considered cancerocidal, i. e., approximately 10,000 rem per gram of tissue, was tolerated well by the dog's larynx. Postoperative edema sufficient to require tracheotomy did not occur in any instance, but postinjection edema was usually present to some degree. When the concentration of the radioactive isotope was increased so as to deliver approximately 60,000 rem per gram of tissue, ulceration and necrosis frequently occurred (Fig. 9). These complications were most apt to be found over the interior of the cricoid cartilage, where the mucosal lining is closely adapted to the cartilage, but no site was immune. The destruction of normal mucosa may be extensive, exposing large areas of cartilage and forming necrotic ulcers. Involvement of the cartilage itself, however, was not encountered. Studies midway between "minimum" effective cancerocidal doses which are nondestructive to the normal tissues of the larynx and the dosage that is destructive have not been made, so that the end-point of maximum dosage which can be tolerated has not yet been determined. Studies necessary to determine this are in progress. Details will be reported upon at a later date.

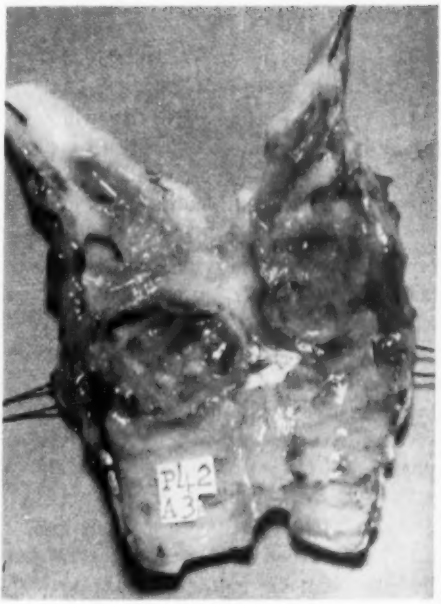
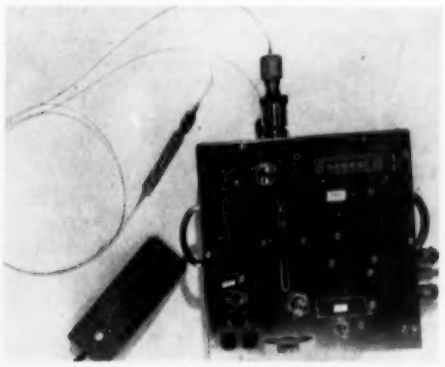


Fig. 9.—Dog larynx eight weeks after injection. Radionecrosis of larynx from injection of 60,000 rem per gram.

* Designed by Dean P. Gamble and Raymond L. Libby, University of California Medical School at Los Angeles.

Fig. 8.—The Gamble-Libby radioisotope injector. A variety of needle points are available for all special purposes.



Conclusions

The studies and experiments; therefore, have demonstrated the following:

1. The dye injections have shown that the larynx is divided into compartments anatomically isolated from one another. The compartments have been identified and mapped.

2. Sixty per cent of the radioisotopes injected submucosally into the larynx remain in situ for the observation period of eight weeks, at which time 94% of the equivalent roentgen dose has been delivered.

3. Within a period of a few days after injection, the scans made of the larynx in vivo show that some of the chromic phosphate has migrated into adjacent lymph nodes.

4. The dog's larynx can tolerate doses of 10,000 rem per gram of tissue but not 60,000. The effect of doses between these two doses has not been established.

5. It is possible to inject effectively isolated compartments such as the margin of the true vocal cord (laryngeal bursa) singly. This may prove of interest in the treatment of the frequently found early cancers which begin in the margins of the vocal cord. The injection of such an area under suspension laryngoscopy would be a very simple and possibly curative measure, with minimum vocal disability.

6. We stress the fact that extensive necrosis of the larynx can result from the intralaryngeal injection of excessive amounts of radioactive isotopes. Preliminary studies indicate, however, that the larynx can tolerate cancerocidal doses which are not destructive. The details of this are in the process of observation. Pending further reports, the clinical use of radioisotopes in the treatment of laryngeal cancer, is fraught with danger.

7. It is considered that after proper study of dosage and techniques, the use of radioactive isotopes will provide a potent weapon in the treatment of intralaryngeal cancer.

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Mucocele of the Sphenoid Sinus

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Mucocele of the sphenoid sinus is interesting not only because of its great rarity but also because it has usually been misdiagnosed as a malignant, neoplastic disease.

Definition

A mucocele of the nasal accessory sinuses has been defined as "an accumulation and retention of mucous secretion within an accessory nasal sinus, generally associated with a distention of one or more of its walls" (Dabney [1]).

Incidence

The age at which this condition occurs ranges from the second through the sixth decade of life, the average age being about 40 years. Age, therefore, is of little help in making the diagnosis. It occurs about equally in both sexes. Mucoceles are often slow in developing, so that it is often difficult to determine the time of onset of this condition. In the case reported here it developed within a period of 18 months. In all the world literature some 300 cases of frontal sinus mucocele have been reported. Ethmoid and maxillary sinuses are much less frequent, and not more than 20 to 25 causes of sphenoid sinus mucocele have been described. In this country I have been able to find reports of only three other cases of sphenoid sinus mucocele.

Etiology

The mechanism of development of mucoceles of the nasal accessory sinuses has been variously described. Killian and others (see Howarth [2]) have suggested injury as a cause, and instances have been reported where this indeed appears to be the basis of the condition. On the other hand, Turner [3] presented 10 cases of frontal and maxillary sinus mucocele in which there was no history of injury. Occlusion of the ostium of the sinus by chronic inflammatory changes of the membrane or by tumor growth, congenital narrowing of the duct, and absence of a communication between the sinus and nose have also been suggested as possible causes (Thomson and Negus [4]). However, it is unlikely that such blockage is a basic cause. This is indicated, on the one hand, by the occurrence of mucoceles in many cases where there is no evidence of obstruction and, on the other, by the many cases of obstruction in which mucoceles do not develop. Tamari and O'Neil [5] felt that it was due to a cystic accumulation of fluid resulting from trauma or infection. Benjamins [6] and Dabney [1] also believed that the cause was a cystic dilatation of the mucous glands or a cystic degeneration of the polypoid mucosa. Schüller [7] discussed the possible development of a hypophyseal cyst from the inner or under half of the sella turcica itself. However, there is no adequate proof of this concept from either operative or postmortem findings. Moreover, since the mucocele of the sphenoid is quite similar to that of the other sinuses this theory does not appear to be sound. Linthicum et al.[8] conclude that the onset of these cases is often so gradual, and the course so slow, that it is difficult to assign a definite cause in an individual case, much less accept any single etiological factor which is common to all of them.

Pathology

As reported by Turner,[3] Onodi found large parts of the ciliated surface epithelium of the sinus membrane replaced by layers of

Accepted for publication Jan. 21, 1957.

pavement cells. Beneath the epithelium there was a fibrous connective tissue layer with small-cell infiltration, consisting of spindle cells and polymorphonuclear leukocytes. Blood vessels and scattered mucous glands were also seen. These low-grade inflammatory changes were also present in the underlying bone. Heatly [9] pointed out that the lining mucous membrane was usually thin in comparison with the thickened and often polypoid mucous membrane seen in cases of chronic suppuration. Turner [3] thought the secretion in the mucocele was due to the increased function of the glands consequent to inflammatory changes. At a later stage, the atrophy of the lining membrane and the glands resulted from pressure due to the accumulation of secretion within the cavity. In Benjamins' [6] case of sphenoid mucocele there were numerous complex glands which were cystically dilated. In Rhese's [10] case there was no evidence of an inflammatory process. The contents of the mucocele are chiefly old blood elements, red blood cells, fibrous elements, and large cells. Cholesterin crystals may or may not be present.

The character of the material obtained from mucoceles of the accessory nasal sinuses has been variously described. In van der Hoeve's [11] case it was a nonodorous, brownish-green, tenacious, mucoid substance containing many cholesterin crystals. In O'Shea's [12] case it was a dark, reddish-brown, glary fluid. It has also been described as being thin, syrupy, thick, mucoid, and tenacious. In the case here reported it was found to be a gray-green, mushy, amorphous, sticky substance.

Symptomatology

Because of the proximity of the sphenoid sinus to the ocular nerves, the cavernous sinus, and the brain, extension of disease from this sinus results in symptoms due to involvement of these structures. The particular signs and symptoms will depend on the size of the swelling, the pressure effects upon the adjacent structures, and also on the nature of the involvement.

1. Headaches have been described as pressure headaches on top of the head, in the suboccipital region, and even in the supraorbital region. They are usually worse with an attack of sinusitis, and improve after nasal discharge.

2. Eye symptoms consist mainly of diplopia, blurred vision, and even complete loss of vision; there may be pains in and behind the eye. Litwinowicz [13] stressed the occurrence of amaurosis after the onset of headaches. With frontal sinus mucoceles there may be a painless, progressive displacement of the eye downward and outward.

3. Attacks of unconsciousness have been ascribed to increased pressure in the region of the third ventricle.

4. Pulsation in the sphenoid region has been found after opening the sinus. This was ascribed to the exposure of the dura and the fact that the large vessels and cavernous sinus are in close proximity to the sphenoid sinus.

5. A sensation of egg-shell crepitation on palpation of the anterior sinus wall with an instrument, and palpation of a rubbery tumor mass at the region of the sphenoid sinus have been described. Berendes [14] stated that there is often a nasal secretion with a forward bulging of the sphenoid wall, an appreciation of which may lead to the diagnosis. In his case the condition was discovered unexpectedly as a result of a nasal septum resection. Hajek [15,16] stated that he and Rhese observed a protrusion of the anterior wall of the sphenoid sinus extending over the posterior part of the middle turbinate. Some mucoceles involve the sphenoid sinus and the ethmoidal labyrinth, as in the cases of Myles,[17] van der Hoeve,[11] and Carter.[18]

6. Roentgen films may show erosion of the sphenoid bone, the sella turcica, and adjoining structures. These films have usually been interpreted by the roentgenologist as due to invasion by malignant neo-

plasms and occasionally as due to a cyst of the hypophysis, either intra- or subsellar. Meisels [19] pointed out the value of roentgenographic findings in diagnosis. Schüller [7] stated that on the basis of x-ray pictures differentiation between mucocele of the sphenoid sinus and intra- or subsellar hypophyseal cysts was very difficult. In frontal sinus mucocele Howarth [2] felt that x-ray is of little aid in diagnosis, but others, such as Young,[20] Chamberlin and Parry,[21] and Hartung and Wachowski,[22] thought that a diagnosis could be made on the basis of the roentgenographic and clinical features. Wigh [23] stated that roentgen films never show normal sinus scalloping at the periphery of these mucoceles. This absence of scalloping is a constant feature. However, this is seen most frequently in the frontal and ethmoid sinuses, less frequently in the antrum, and rarely in the sphenoid sinus. Stewart [24] cited two cases of frontal sinus mucocele in which the radiologist insisted on a diagnosis of malignant neoplasm. I have seen no reports where the diagnosis of sphenoid sinus mucocele was correctly made on the roentgenographic findings, probably because of its extreme rarity and, therefore, a lack of familiarity with this condition.

Diagnosis

These patients are usually seen first by the ophthalmologist, because of the eye symptoms. When the skull and sinuses are examined by roentgen ray, the bone destruction is usually interpreted as being due to malignant neoplastic invasion of such extent as to preclude operative intervention, and therefore deep x-ray therapy is instituted. When this is found to be ineffective, exploratory surgery is undertaken and the condition is discovered.

In the case reported by Anthony and Williams [25] from the Mayo Clinic, roentgenograms were interpreted as showing extensive malignant destruction of the floor and dorsum sellae, the body of the sphenoid bone, both ethmoid areas, and the medial wall of the left orbit. Roentgen therapy was given because of the presumptive diagnosis of an inoperable malignant neoplasm. One and one-half years later the patient returned, with little change in her physical examination. A decision was made to explore the lesion via an external route. The ethmoid and sphenoid sinuses were found to be filled with a mass of gummy, rubbery mucus. The dura was found exposed over the roof of the sphenoid and part of the ethmoids. The tissue removed was inflammatory mucous membrane with dilated mucous glands and masses of inspissated mucus.

Bilchick [26] reported the case of a 52-year-old man with rapid loss of vision in the left eye. Roentgen films showed a large defect in the sella turcica with involvement of the sphenoid and ethmoid sinuses and the left orbit. It was observed that the fairly definite margins suggested the possibility that this was a retention cyst, but carcinoma could not be excluded. The ophthalmologist diagnosed it as a neoplasm of the sphenoid sinus and requested a biopsy. When the sphenoid sinus was opened there was a gush of about 15 cc. of yellow fluid. The cyst lining and mucous membrane were removed. On microscopic examination it was found to consist of several layers of atrophic cuboidal epithelial cells resting on a dense fibrous membrane. Vision was rapidly restored.

In the case reported by Linthicum et al.[8] a 54-year-old man who had had several sinus operations during the preceding 24 years developed increasing left fronto-occipital headaches and had two attacks during which he lost consciousness. Roentgen films showed two irregular radiolucent areas in the occipital bone, enlargement of the sella, absence of the posterior clinoids, and erosion of the left anterior clinoid. A diagnosis of cholesteatoma was made. A suboccipital craniotomy was done, but no cholesteatoma was found. A few days later, vision in the left eye became blurred. A diagnosis of suprasellar meningioma or cyst was made, and a left frontotemporal osteoplastic craniotomy was done. A bluish elevation was found at the base of the skull, measuring 4

cm. in diameter. On aspiration, 9 cc. of thick greenish-brown material was obtained. After opening this tumor it was found to extend into the sphenoid sinus. The aspirated material contained cholesterol crystals, considerable pus, and a few red blood cells. There were no bacteria. One month later an intranasal operation was performed. The anterior wall of the sphenoid sinus was very thin and started to pulsate, so nothing further was done. Later, several aspirations of the sphenoid cyst were made. The patient developed increasing headaches. One year later he developed a convulsive seizure on the right side of the body and died. The postmortem examination showed an abscess of the left frontal lobe. There was no bone on the roof of the left sphenoid sinus. The cavity measured $5 \times 2.5 \times 2$ cm.

Linthicum et al.[8] conclude that "the diagnosis of sphenoid sinus mucocele is difficult, has seldom been made preoperatively, and often has been discovered inadvertently."

Differential Diagnosis

This condition has to be differentiated from various types of benign and malignant growths. Some of these are osteomas, angiomas, lymphoid tumors, dermoid, hydatid, and pituitary cysts, xanthomas, cholesteatomas, lyomas, meningiomas, gummas, epidermoid carcinomas, neurosarcomas, and fibrosarcomas. Aspiration of thick, brownish, tenacious fluid and roentgen findings help to establish the diagnosis. However, in the last analysis, only a microscopic study of a biopsy specimen or frozen-section specimen can yield the correct diagnosis. Hajek[16] stated that a number of cases reported as mucoceles cannot be proved under critical analysis.

Treatment

So few cases of mucocele of the sphenoid sinus have been reported that the method of treatment cannot be discussed in great detail. It would seem obvious that the aim of surgery should be twofold: (1) the removal of the pent-up secretion and, if possible, the wall of the mucocele in its entirety and (2) the establishment of adequate drainage from the sinus into the nose. Berendes[14] felt that the most suitable method for treating a mucocele of the sphenoid sinus was an operation through the ethmoids, to provide adequate drainage into the nose. The question of subsequent infection of the cystic cavity was of much greater importance before the advent of the chemotherapeutic and antibiotic drugs.

Szende[27] reported on operations in 21 cases of mucocele. Of these, three were in the frontal, ethmoid, and sphenoid sinuses simultaneously. However, the review mentioned no specific facts regarding the diagnosis and treatment of sphenoid sinus mucoceles.

In the case of frontal sinus mucoceles, it is generally agreed that radical exenteration through an external incision and establishment of adequate intranasal drainage should be the twofold goal of treatment.

Complications

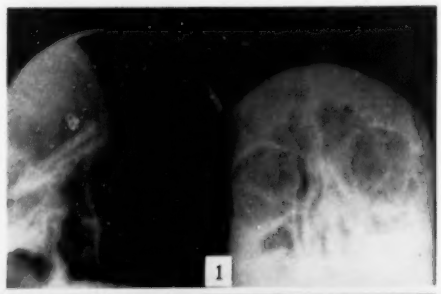
Complications are due to pressure or spread of infection or both.

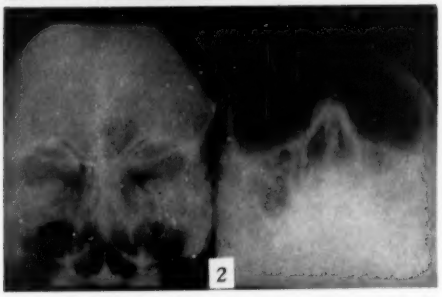
1. Pressure on the surrounding structures may be manifested by paralyses of the ocular muscles, both by direct pressure and by pressure on the nerves. Blurred vision and blindness may develop due to pressure on the optic nerve and the central retinal artery.

2. In the event of suppuration, a spread can occur to (*a*) the frontal or sphenoid bones, causing an osteomyelitis; (*b*) the orbit and its contents; (*c*) the meninges; (*d*) the brain, and (*e*) the venous (cavernous) sinuses.

Report of a Case

A white woman, aged 41, was referred to me by Dr. Charles W. Elkins, a neurosurgeon, on Sept. 11, 1954, with the request that I examine the nasopharynx in order to rule out the presence of a lymphoepithelioma. I was told that a malignancy of the base of the skull was suspected because of the roentgen findings.





Figs. 1 and 2.—X-rays taken at St. Mary's Hospital, Tucson, Ariz., March 3, 1953, before the first operation, performed by another otolaryngologist. These show clouding of the left ethmoid, sphenoid, and maxillary sinuses.

The patient stated that, while visiting her daughter in Baltimore nine months previously, she developed diplopia and a pain over the left eye. She saw two ophthalmologists, one month apart, and was told by each that her double vision occurred because her eyes were tired and that there was nothing essentially wrong with her eyes. On her return to Tucson she visited her nose and throat doctor, who recommended that she see a local ophthalmologist. This she did, and again she was told that there was nothing essentially wrong with her eyes. Her family physician then advised her to see a neurologist, who told her that he suspected a tumor of the brain and advised roentgen-ray examination of the skull. He also told her to report when she had another attack of pain over the eye so that he could inject the nerve there. The roentgenologist reported that there appeared to be "extensive neoplastic disease which is both intrasellar and invasive of the posterior superior nasopharynx producing destructive and osteolytic changes in the anterior portion of the base of the sphenoid, chiefly to the left." Basing his decision upon these findings, Dr. Elkins made arrangements for deep x-ray therapy.

The eye, ear, nose, and throat examination revealed the following: The nasopharynx was entirely normal. The ear drums were normal and the hearing good. Polyps in the left side of the nose caused complete obstruction. There was no definite sinus tenderness anywhere. Diplopia was present only on looking far to the left, and the patient stated that the double vision was much better than it had been some months previously. Her vision was 20/20 in the right eye and 20/20— in the left eye. The fundus of both eyes appeared normal.

The next day I reviewed the x-ray films of the skull and obtained the additional information that the patient had been operated on by another otolaryngologist about a year and a half previously for the removal of polyps in the left side of her nose. She also stated that she had had sinusitis as far back as she could remember and that during the past six months she had had pains in the left eye and rather severe pressure headaches all over her head. The pain started above the left eye, went over the top of the head, and then down into the left occipital region. It did not radiate into the shoulder or back. It occurred almost daily and lasted from one to three hours.

Fig. 3.—This x-ray and that shown in Figure 4 were taken by Drs. Hayden and Present, of Tucson, Aug. 10, 1954, before my first operation. These show destruction of the anterior one-fourth to one-third of the base of the sphenoid, chiefly to the left of the midsagittal line, with erosion of the tip of the left petrous pyramid. There is an apparent increase in the length of the anterior clinoid processes of the sella turcica due to erosion of the sella forward, downward, and backward. The posterior clinoids appear almost completely eroded. There is a loss of bony sharpness of the floor and anterior wall of the sella.

Fig. 4.—See legend for Figure 3 for details.

In view of the extensive bony destruction of the base of the skull (more marked on the left), the long history of sinusitis (also mainly on the left side), the recent improvement in the diplopia, the almost normal vision, and the apparent relative good health of the patient, I felt that we were probably dealing with a mucocele of the sphenoid sinus rather than a malignancy. I conveyed this impression to Dr. Elkins. A few days later I discussed this case with the otolaryngologist who had operated on the patient 18 months previously and he told me that during the operation he was astonished to see a fairly large amount of dark, thick material, which oozed out as he snared some polyps on the left side of the nose. He said that he could not determine the trouble and discontinued the operation. With this additional information, I felt more convinced that the diagnosis of mucocele was the correct one.

The report of the x-ray films taken at St. Mary's Hospital, in Tucson, on March 3, 1953 (before the first operation), stated that there were " . . . changes in the left ethmoid region with apparent loss of bone definition. Although neoplasm cannot be ruled out, it is probably due to benign polypoid hypertrophy." The left sphenoid sinus was moderately cloudy.

In view of the great rarity of this condition and the fact that the diagnosis of mucocele was only tentative, the neurosurgeon and roentgenologist decided that it would be wiser to treat this patient with deep x-ray therapy and note the results before undertaking operative exploration. Therefore, she was given five weeks of almost daily deep radiotherapy under the guidance of Dr. Portmann.

She was observed for approximately two months after these treatments, and no apparent effect was noted. The x-ray films taken after the treatment showed no change from that of the previous examination. On Dec. 8, 1954, an intranasal operation was performed under general anesthesia.

Findings.—The left side of the nose was jammed with polyps. During their removal there was considerable bleeding due to the marked congestion. The middle turbinate was removed in toto. The polypoid membrane in the ethmoid space was removed as thoroughly as possible. On palpation with a probe, the bony roof of the ethmoid cells was found to be absent, probably due to erosion. Because of the danger of injuring the dura, the polypoid membrane was not removed as thoroughly as I would have liked, but under the circumstances a satisfactory removal was accomplished. The anterior sphenoid sinus wall was probed and found to be of normal bony consistency. However, after entering the sphenoid sinus through its ostium, the probe did not hit a posterior wall, but entered a cavity, the end of which I could not feel.

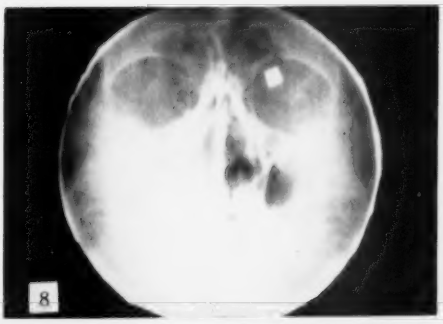
The anterior wall of the sphenoid sinus was removed with sphenoid punches. The cavity contained a gray-green, mushy, sticky, amorphous substance which was very difficult to remove. A relay of three nasal suction tubes was used, because of the repeated clogging; then an abdominal suction tube was inserted and various types of forceps were tried. It took more than an hour of constant removal to cleanse the cavity completely. It was then seen to be lined by a smooth, somewhat congested-looking membrane. The bony roof of the sphenoid sinus and of the cavity produced by the mucocele was absent, so that pulsating dura was visible. There was no sign of any malignant growth. So far as I could judge, the cavity measured about 5×4×4 cm. The nasal septum was pushed to the right; posteriorly, the bone and cartilage appeared to be absent. The nose was packed with iodoform gauze, and the patient left the operating room in good condition. She was placed on antibiotic therapy.

The next day she was out of bed, and two days later she was able to leave the hospital.

Pathology Report by Dr. Fuller.—The contents of the cavity were described as follows: There are several dozen irregularly shaped masses of extremely friable, opaque, amorphous, cheesy, pale-green substance in which no tissue of fixed cell type can be identified. The material is largely amorphous, eosinophilic substance. The impression obtained is that poorly preserved cells are imbedded in this debris, possibly sanguinomucopurulent exudate. There is no evidence of neoplasm. Diagnosis: probably mucocele of the sphenoid sinus.

Follow-up was done in visits to my office. After a period of about one month she felt fully recovered. She was able to breathe normally through the left side of her nose, and the headaches and pains over the left eye had disappeared. Her vision was normal, and there was no diplopia. She felt so well that she accepted a part-time job in addition to her regular housework.

Figs. 5, 6, and 7.—X-rays taken in my office on Feb. 10, 1955, after surgery, showing extent of mucocele cavity as delineated by iodized oil (Lipiodol) instillation.



Figs. 8 and 9.—X-rays taken in my office on Oct. 27, 1955 (before second operation), showing clouding of ethmoid and maxillary sinuses on the right side.

She was seen at irregular intervals during the next five months. During this time she had no difficulty with the left side of her nose and head.

Eleven months after the operation she returned to the office stating that she was beginning to have nasal obstruction and pressure headaches on the right side. Examination showed marked polyp formation and some secretion in the right naris. X-rays of the sinuses showed clouding of the right antrum, ethmoids, and sphenoid. I advised, and she agreed to have, nasal surgery on the right side.

An intranasal sphenoethmoidectomy and antrotomy was performed under general anesthesia. Upon removal of the polyps and the middle turbinate, about three teaspoonfuls of dark, amorphous, mushy material was released from the ethmoid sinuses. On entering the sphenoid sinus only thickened membrane and mucopurulent secretion was seen. This was completely removed. The posterior wall was intact. The antrum was then opened and also found to contain thickened membrane and mucopurulent secretion. The mushy material obtained from the ethmoid sinuses was quite similar to that found in the left sphenoid sinus during the previous operation, except that it was much darker.

The patient again made a rapid, uneventful recovery. She was followed in the office, and at no time did she have any symptoms relating to her sinuses. Her nose has been perfectly clear, with practically no secretion at any time. The sinus cavities have remained wide open. She was last seen a year after her second operation, at which time she was in excellent health, with no complaints referrable to her nose and sinuses.

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The Possibilities of Betatron Treatment in Carcinoma of the Paranasal Sinuses and of the Larynx

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My role in joining the symposium is to discuss in general the possibilities of betatron therapy in cancers of the nose-and-throat area and its relation to conventional x-rays, and to present a few irradiated cases. The main question is what is the sense of using megavoltage radiations in lesions which are close to the surface and to which conventional x-ray may also deliver an adequate, high tumor dose.

The betatron may produce two types of radiation: high-energy x-ray beam and high-energy electron beam. Their depth dose distributions, and accordingly their indications, are entirely different. Figure 1 shows the differences in depth dose distribution. In the curve of conventional 400 kvp the maximal dose is at the surface and the decrease is fast, so that at 10 cm. depth the dose is less than 40% of the maximum. In the curve for the 23 mev betatron x-ray beam, the dose is insignificant at the surface, and it remains relatively low in the first 3 cm., reaching the maximum at 4 cm. depth. The decrease is slow, so that in 10 cm. depth it is still 80% of the maximum. The curve for the high-energy electron beam shows that the absorption is rather homogeneous up to a certain depth, and beyond it the dose drops rapidly.

The possible advantages of betatron x-rays over conventional x-rays are (1) greater penetration (a higher tumor dose can be delivered to any depth of the body); (2) lower surface dose (therefore skin damage cannot be expected even after excessive dosages); (3) insignificant side-scattering, sharper beam limitation (therefore normal tissues outside of the beam receive no radiation); and (4) less bone absorption (therefore the risk of bone necrosis and bone marrow depression is less).

The indications for betatron x-rays may be divided into three groups: 1. The main indications are deep-seated lesions, because a higher tumor dose can be delivered with less general, less skin and bone reactions and damages. 2. Potential indications are less deeply seated lesions, to which conventional x-ray also may deliver an adequate tumor dose, but with the use of betatron x-rays the risk of skin and bone damage is less, and the volume of irradiated normal tissues is less. 3. Also potential indications are extensive or metastatic conditions; in these cases one can employ spray radiation of large body parts or of the whole body for palliation. The betatron secures more homogeneous absorption in large body parts, higher dose in all lesions, and less bone marrow depression. In the nose and throat cancers, only the second group of indications is of interest.

In treatment of sinus carcinoma the betatron x-ray beam would have both advantages and disadvantages. The advantages would be less risk of skin reaction and bone damage and, in lack of side-scattering, diminished risk of eye damage. Disadvantages are the high exit dose, and, mainly, the low surface dose, because tumor segments which are close to the surface in advanced cases would receive an insufficient

Accepted for publication Dec. 28, 1956.

From the Department of Radiology, University of Illinois College of Medicine.

Read before the Joint Meeting of the Chicago Laryngological and Otological Society and the Chicago Roentgen Society, Nov. 8, 1956.

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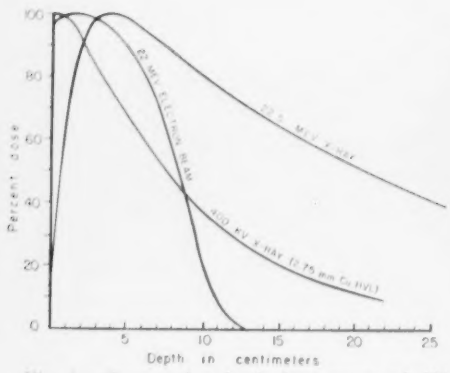

Fig. 1.—Comparative depth dose curves of 400 kv. conventional x-ray, 22.5 mev betatron x-ray, and 22 mev betatron electron beam.

dose. In our material we had no opportunity to treat sinus cases in which the betatron x-rays were preferable to conventional x-rays.

More ideal is the dose distribution of the high-energy electron beam. Its advantages are the following: 1. Rather homogeneous absorption to a certain depth, therefore the tumor regression is more uniform and gradual in all layers of the tumor. 2. Beyond this depth the dose drops rapidly, therefore the nearly normal tissues will get much less radiation and the reactions will subside faster and better than after conventional x-rays. The depth of useful penetration can be selected as desired in the individual cases between 3-8 cm. from the surface at our energies. 3. Less bone absorption, therefore the risk of bone and cartilage damage is less.

A slide showed, e. g., that the mucositis of the tongue stops in the midline in the selected depth. These advantages are valid for the great majority of sinus carcinoma cases, without disadvantages. If our electron beam is available, we prefer it in sinus cases to conventional x-rays. The skin reactions to the electron beam are similar to those from the conventional x-rays. Photographs taken in two cases are presented.

In the first case a widespread postoperative recurrence of an adenocarcinoma of the right antrum was present, which was in part

Fig. 2.—Healed area of palate defect after electron-beam irradiation of extensive postoperative recurrence of adenocarcinoma of the right maxillary antrum.

surgically excised. The extensive residual tumor included also the oral surface of the surgical palate defect. After electron-beam treatment the tumor disappeared entirely. Figure 2 shows the healed area of the palate defect with smooth mucosal membrane, after mucositis had rapidly subsided.

The second case was a neglected epidermoid carcinoma involving both maxillary antra, the nasal cavity, palate, and vestibulum, with antrorhino-orovestibular communications. The patient was treated for 10 months with the diagnosis of palate ulcer.

Fig. 3A (Patient with epidermoid carcinoma involving both maxillary antra, the nasal cavity, palate, and vestibule).—Swelling of right cheek, with absence of nasolabial groove.

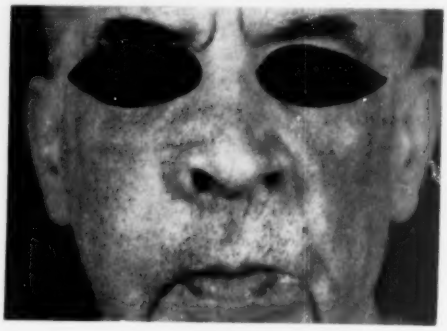

Fig. 3B.—Maximal skin reaction after electron-beam treatment; reappearance of nasolabial groove.

Fig. 3C.—Four weeks later, regressed skin reaction.

Because the depth of the lesion exceeded our maximal 8 cm. penetration, we treated it through two opposing fields.

Figure 3A shows the characteristic swelling of the right face, with absence of nasolabial fold, Figure 3B the maximal skin reaction, and Figure 3C, four weeks later, the regressed skin reaction and reappearance of the nasolabial fold. Figure 3D shows the fungating tumor masses broken through the hard palate, and Figure 3E the healed palate area with the bony defects by tumor destruction.

I wish to bring up here a controversial problem, being in the company of naso-laryngologists. It is a traditional belief that the results of radiotherapy are better if inoperable large antral sinus carcinomas are reduced in size by partial resection. This was true perhaps in earlier eras, when radium or lower voltage x-rays were applied with inadequate penetration. Since the use of higher energies, 200 kv. or more, with adequate depth dose, this practice is obsolete. Rather, the impression is that the preradiative tumor amputation, except for special indications, impairs the chances of the patients due to several factors. In the delay of several weeks or months due to surgery, the disease may progress significantly or it may invade the vascular and lymphatic pathways of generalization. The incomplete surgical procedure may inoculate cancer cells into the vicinity and into the metastasizing pathways. We have seen repeatedly that after incomplete removal the tumor burst forth suddenly and the downhill course became more rapid. Surgical derangement of tumor tissue and tumor bed,

Fig. 3D.—Before treatment, fungating tumor masses broken through the hard palate.

Fig. 3E.—After treatment, healed palate area, with visible antronaso-orovestibular communications by tumor destruction.

and postoperative infections may impair and complicate the effects of radiations.

The localization of the larynx is a fortunate one, inasmuch as it is easily accessible to adequate dosage by any kind of irradiation, including conventional x-rays, betatron x-rays, and betatron electron beam. The betatron x-ray has the advantage over conventional x-rays in that the skin reaction and risk of cartilage necrosis are less. The electron beam has the advantage that the risk of cartilage necrosis is less and that the mucosal reactions recover faster and better than with the use of conventional x-rays. Therefore, we prefer, if available, the betatron x-rays to the conventional x-rays, and the electron beam to the high-energy x-ray beam.

We have treated 10 larynx cancer cases; 7 of them refused surgery, 6 were treated by x-ray beam, and 4 by electron beam of the betatron. Three of the ten patients died, all of the third stage. Two were treated in the first period of our betatron work. One, who refused any further medical procedure, except for an emergency tracheotomy, died of recurrent disease with neck nodes. We know now that the given dose of 6300 betatron r in 45 days was insufficient. The second patient died with symptoms of post-radiation edema, also after tracheotomy; residual tumor was not proved, but the possibility that it was present could not be excluded. In this case the given dose of 9025 r was delivered for technical reasons in 32 days, perhaps too fast. The third patient died at the age of 85 years seemingly without local recurrence after three and one-half years. The out-of-state death certificate stated lung carcinoma and pneumonia as the cause of death.

Fig. 4.—Maximal skin reaction in larynx carcinoma after 10,000 r tumor dose of betatron x-ray.

Seven patients are living without tumor evidence, one for over five, one over three, three over two years, one over one year, and one over six months, respectively. Using the classification of Nielsen-Strandberg, three patients belonged in Stage 2, six in Stage 3, and one, with neck nodes, in Stage 4. In the latter case radical neck dissection was performed in the meantime.

In the majority of the cases without neck nodes small radiation fields of 3 cm. in diameter were used (Fig. 4) and proved to be satisfactory. It is known that neck nodes develop later in only a small, less than 5%, percentage of the cases which can be cured by surgical dissection or radon seeding. The small fields give the possibility of larger tumor doses with less radiation reactions and damages.

Figure 5*A* shows the infiltrating, shiny involvement of the whole left vocal cord,

Fig. 5.—*A*, infiltrating carcinoma of the whole left vocal cord, with restricted mobility. *B* and *C*, healed cord in different positions of phonation after electron-beam irradiation.

with restricted mobility. *B* and *C* of Figure 5 demonstrate the healed cord in different positions of phonation, and the subsided, absent mucosal reaction eight weeks later, after completed electron-beam therapy. The patient has been asymptomatic for over 13 months.

In conclusion, it can be stated that, in spite of the fact that conventional x-ray may also deliver an adequate curative dose to carcinomas of the sinuses and larynx, the x-ray beam and electron beam of the betatron megavoltage irradiation have definite advantages over conventional x-rays, not so much in their curative aspect as in lessened discomfort and less radiation. The clinicians know very well what the decreased discomfort during and after radiotherapy and the lessened risk of skin, bone, and cartilage damages mean clinically for the patients.

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Conservative Management of Chronic Otitis Media

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Conservative management of chronic otitis media controlled the infection in 70% of the last 100 cases reviewed in my private practice and from the otolaryngological department of the San Diego County General Hospital. Only those patients who have followed the recommended treatment and have been under my personal supervision are considered.

In this study, in order to be considered controlled, the infection must be eliminated and not more than a very scant nonpurulent moisture remain. An occasional short-lived flare-up may come with acute respiratory infections.

A thorough history and physical examination are done. This includes an audiogram, culture and sensitivity studies of the discharge, and x-rays of the mastoids and, if needed, other areas, e. g., sinuses and chest.

The general care of the patient is most important. Coexisting diseases, such as anemia and infections of the urinary tract, are treated by the referring physician or a colleague. A study of the living pattern of the patient then is made, and he is encouraged to follow these eight general rules of health:

1. Adequate, balanced diet.
2. Adequate ventilation, fresh air, and sunshine.
3. Abundance of fresh drinking water.
4. Good elimination.
5. Adequate exercise.
6. Adequate rest and relaxation.
7. Wholesome mental outlook on life.
8. Abiding faith in God or a Supreme Being.

Diseases of the sinuses, nose, and throat must be controlled through the management of allergy and infection, and the elimination of obstructions to the Eustachian tube, nose, and sinuses. By making skin tests and other allergy studies, the offending agents are discovered. All allergens are either eliminated or the patient is desensitized to them, using the Hansel[1] minimal dosage technique. Staphylococcus toxoid and vaccines are beneficial to some patients. The patient should avoid dusts, fumes, and other respiratory irritants. Many persons must discontinue tobacco smoking.

Purulent respiratory infections are eliminated by the use of specific antibiotics after culture and sensitivity studies have been made. Antrum irrigations and nasal lavage are often needed to remove mucopurulent sinus discharge.

Minor sinus surgery, polypectomies, and submucous resections of the nasal septum and hypertrophic turbinates are used whenever it is necessary to promote adequate drainage and ventilation of these structures and to provide a normal air-flow pattern in the nose.

Obstructions to the Eustachian tube and infections in the tonsils and adenoids that do not respond to other types of simple treatment are an indication for the removal of adenoids and/or tonsils. The adenoidectomy is done under direct vision and is checked by using the nasopharyngeal mirror to be certain that all obstructing lymphoid tissue is removed from about the Eustachian tube area. If evidence persists that the Eustachian tube continues to be obstructed, then radium or x-ray therapy is given to the nasopharynx. Frequent tubal inflations are used. Occasionally bouginage is indicated.

Specific treatment of the ear usually begins with the first visit and is carried on

Accepted for publication Feb. 13, 1957.

From the Department of Otolaryngology, San Diego County General Hospital.

Read before the Sixth International Congress of Otolaryngology, Washington, D. C., May 5-10, 1957.

simultaneously with the other therapy already mentioned. Here again, culture and specific antibiotic studies are made of the discharge. If the ear obviously shows pathology which will not respond to conservative treatment, a mastoidectomy is recommended at this time. However, usually specific antibiotics are given topically and systemically. Obstructions to free drainage of the ear, such as aural polyps and osteomas, must be removed. In some cases, myringotomies are indicated. Curettement and silver nitrate are used to control granulated areas if these are accessible. Small cholesteatomas can often be handled with curettement and irrigations with alcohol.

Both the wet and dry methods of ear therapy are used. I have found the following nonantibiotic preparations to be of value in the treatment of chronic otitis media: glycerite of hydrogen peroxide with urea, 1% acetic acid solution, hydrogen peroxide, a saturated solution of boric acid and 70% alcohol, nitrofurazone (Furacin) solution, Burow's solution, and glycerin. When using the dry method, the following powders were found to be effective: sulfonamide, antibiotic, boric acid, and iodine.

The accompanying Table gives a summary of the findings in our survey. The average duration of discharge was 8.06 years, the longest being 60 years and the shortest 3 months. The average age of the patients was 30.08 years, the oldest patient being 77 years and the youngest 10 months. Forty-nine per cent of the patients were treated for coexisting diseases. Nine per cent had minor nose and sinus surgery other than antrum punctures. Thirty-four per cent had tonsillectomy and/or adenoidectomy. Twenty-five per cent had radiation therapy to the nasopharynx. Forty-six per cent had minor ear surgery. The average duration of treatment was one year, the longest period being four years and the shortest one week. Thirty per cent required major ear surgery. Infection was controlled in 96% of the whole group.

A Summary of the Findings in One Hundred Cases of Suppuration of the Temporal Bone

Average duration of discharge (Longest 60 yr.; shortest 3 mo.)	8.06 yr.
Average age of patients (Oldest 77 yr.; youngest 10 mo.)	30.08 yr.
Coexisting diseases treated	49%
Nose and sinus surgery	9%
Tonsillectomy and/or adenoidectomy	34%
Radium and/or x-ray therapy	25%
Minor ear surgery	46%
Average duration of treatment (Longest 4 yr.; shortest 1 wk.)	1 yr.
Major surgery	30%
Infection controlled	96%

Treatment for chronic suppurative otitis media can best be given by a man trained in the entire specialty of otolaryngology. When the nose, sinus, and throat conditions are adequately handled, the ear infection will respond more readily. Conservative measures faithfully carried out show that nearly two out of three patients with stubborn chronic suppuration of the temporal bone can and do improve to the satisfaction of both the patient and the otolaryngologist.

Summary

One hundred cases of chronic suppuration of the temporal bone are reviewed. Management includes a thorough history, physical examination, x-ray and laboratory studies, and treatment of coexisting diseases. Allergy, infection, and obstructions of the nose, sinuses, and throat are controlled or eliminated, while the patient cooperates by following the eight basic rules of health. Only 30% of the patients required major ear surgery; 96% of the ear infections were controlled.

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Plastic Surgery

Summaries of the Bibliographic Material Available in the Field of Otolaryngology for 1955

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Introduction

Hearing in Patients with Congenital Meatal Atresia—The large majority of children with unilateral congenital meatal atresia have a normal internal ear on the affected side. This end-organ of hearing is constantly stimulated by sound vibration through the bone, and probably no reduction in hearing occurs if surgical interference is delayed until the infant is old enough to have an accurate audiometric test. When one is dealing with extremely nervous parents psychogalvanometric testing may be indicated. If the audiometric testing at the age of 3 to 4 years demonstrates normal hearing in the uninvolved ear and a relatively normal internal ear on the affected side, operation is probably not indicated. In any event, it is best to reconstruct the auricle first and later provide a skin-lined opening into the antrum behind the constructed auricle. Skin-lined openings made in the canal region through the cartilage substance of the constructed auricle become unsightly draining sinuses and may result in loss of the transplanted cartilage framework.

Patients with bilateral meatal atresia and absent or deformed auricles present a difficult problem; in these instances also it is best to delay operation until the child is 3 to 4 years of age. If the child's speech is delayed a hearing aid is often helpful, but its use requires guidance by a tactful and experienced audiologist who understands children. At about 4 years of age the two auricles are constructed, utilizing diced cartilage from both sides of the child's chest reinforced with diced cadaver cartilage. The right and left ear molds with their content of diced cartilage are then buried in subcutaneous pockets in the right and left sides of the child's lower abdominal region, and the two auricles are constructed in the usual manner.[1] Skin-lined openings into the antrum, with or without fenestration, are formed through the mastoids behind the constructed auricles.

The patients who have had skin-lined openings made before construction of the auricles are extremely difficult to manage. The draining sinus tract endangers the transplanted cartilage, since the latter must be buried beneath the skin around this fixed point.

Supporting Framework for Auricles.

The only tissue suitable for supporting an external ear in a child is autogenous cartilage.[2] When sufficient cartilage cannot be obtained from the child's chest wall, the autogenous cartilage may be supplemented by the addition of homogenous bank cartilage or living homogenous cartilage from a parent.

On the basis of successful (with long survival time) skin switches between mothers and infants and the early rejection of skin transplants from fathers to infants, the mother should serve as the cartilage donor[3,4] when living homogenous cartilage is used.

Accepted for publication Feb. 28, 1957.

Face

Over a period of approximately seven years Owens [5] has used a lateral neck flap, usually rectangular, and established just anterior to the hair-bearing line, over the mastoid area, for repairing extensive defects of the face. The compound pedicle is formed by incisions carried down through the full thickness of the skin, the underlying fat, the platysma muscle, and the cervical fascia and down to and including the sternomastoid muscle. Advantages of such a compound pedicle are there is always adequate tissue for extensive facial repairs and it offers bulk of tissue. Because of the thickness of this implant and because of the abundant blood supply one is able to transplant satisfactorily either bone or cartilage grafts. The compound neck pedicle fulfils all requirements of color and texture. Owens has found the method to be successful and entirely satisfactory.

The article is well illustrated.

De Cholnoky [6] presents a report on the repair of cheek defects of different sizes by interpolating sliding skin flaps from neighboring areas. He demonstrated the satisfactory cosmetic results obtained from sliding cheek flaps in defects in various facial locations due to excision of a basal-cell

Fig. 1.—The relationship of the platysma muscle to the sternomastoid muscle. Superior inset reveals explanation for adequate blood supply to the pedicle outlined with its base superior to the logical blood supply. Note relationship of posterior auricular artery as it ascends to give off the sizable branch to the sternomastoid muscle. In the superior right inset, the thickness of tissue incorporated on the outlined compound pedicle clearly demonstrates the close proximity of the major vessels of the neck when tissue, including the sternomastoid muscle, has been dissected upward. (Reproduced by permission from Owens, N.: Plast. & Reconstruct. Surg. 15:372 [Fig. 1A], 1955, Williams & Wilkins Company.)

Fig. 2.—The flap has been dissected up to include all soft tissue down to the carotid sheath. The under-surface of the sternomastoid muscle is shown with its blood supply. The size of this compound pedicle can be made much larger if requirements demand. (Reproduced by permission from Owens, N.: Plast. & Reconstruct. Surg. 15:373 [Fig. 2], 1955, Williams & Wilkins Company.)

or squamous-cell carcinoma. In one patient the sliding cheek flap was used by placing the incision in the nasolabial fold; in another, from preauricular and parotid regions to the temporal area; in a patient with a recurrent tumor in the zygomatic region, a sliding flap was developed along the previous incision at the front of the ear, with deep undermining down to the neck.

The use of skin grafts about the head and neck is discussed by Huffman and Lierle.[7] A concave bed with an irregular surface may call for the graft to be laid in the wound bed very loosely so that it may be in intimate contact with all parts. A convex bed with a smooth surface may allow the graft to be applied with considerable tautness. The degree of dressing pressure applied over a graft should be about the same as that to which skin is subjected in its normal position. Where oozing from the bed cannot be controlled, the dressing must be tight enough to be hemostatic. Grafts put into the mouth should be taken from some relatively hairless area. Generally it is best to apply the graft that is to provide the lining for through-and-through construction of a cheek or lip before the flap is moved to the defect.

As stated by Lewis,[8] unduly wide, depressed, irregular, elevated, or bumpy scars can be improved. Treatment of scars resulting from infections, from automobile acci-

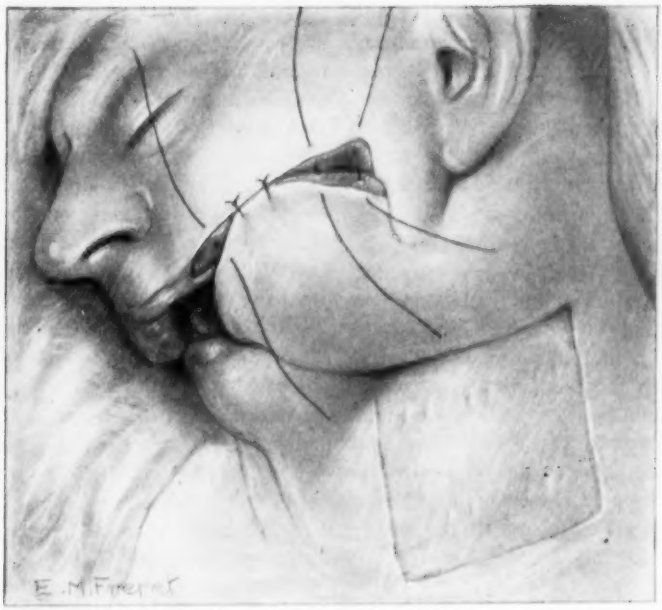


Fig. 3.—The manner of attachment of compound pedicle to superior margin of defect of the cheek, as the pedicle is brought forward and upward. (Reproduced by permission from Owens, N.: Plast. & Reconstruct. Surg. 15:377 [Fig. 7], 1955, Williams & Wilkins Company.)

dents and other injuries, and burn scars is fully discussed.

Eight cases of fibrous dysplasia of the facial bones, as presented by Kanthak, Hamm, and Yarn,[9] were studied from the viewpoint of etiology and therapy. It seems likely to them that conservative therapy is most appropriate. Usually they attempt to elevate mucosal flaps if the lesion is situated on the maxilla, mandible, or zygomatic bone, and shave down the excess bone formation so that the involved area will conform with the opposite side. After this procedure the mucosal flaps are replaced and sutured, and healing generally occurs. As a rule in the cases here reported the patients were treated in this way. In view of the benign nature of the lesion, Kanthak and his colleagues feel that massive resection of the bones is seldom justified.

Dawson and Muir [10] report two cases of frontonasal glioma in children which were treated surgically. The mass at the root of the nose should be approached extranasally, according to the authors, and can be shelled out easily once the right layer is entered. In one patient the stalk passed through a small hole between the nasal bones and ended in a pocket between the septal mucosa and septum.

Eye

A two-stage procedure for the repair of colobomas of the upper lid is described by Cutler and Beard.[11] It utilizes a full-thickness flap of the lower lid, mobilized and carried upward beneath a bridge of the lower lid margin, to fill the defect in the upper lid. The conjunctiva, muscle, and skin of the flap remain connected with its upper edge by connective tissue.

After about two months, in the second stage, the united conjunctiva and skin are separated, the bridge is retracted downward and the flap is divided at the marked upper lid margin, and the conjunctiva and skin edges are joined.

Hopen [12] reports an interesting case of congenital eversion of the upper eyelids. Markedly chemotic, thickened, edematous,

totally everted upper eyelids were present, without other anomalies. After failure of conservative methods, the upper and lower eyelids of both eyes were sewn together. Seven days later, the sutures were removed. The eyes closed tightly, with the lids in good apposition, even when the child was crying.

Hendrix [13] describes Sarwar's method for surgical correction of congenital and paralytic ptosis of the eyelid. A strip of orbicularis oculi is raised transversely and may be based medially or laterally. The orbicularis muscle is brought down through a tunnel through the tarsal plate and passed back up through the tunnel. The tip of the muscle is sutured back in the same location. The lid is pulled up. Excess of skin in the lid may be excised. The lower lid is pulled up. Additional elevation of the lid can be obtained by forcibly raising the frontalis muscle.

Hendrix has not had as good results in children as in teenagers and adults. He considers muscle training essential.

Ear

Steffensen [14] reports the follow-up on a series of cases in which the external ear was reconstructed by his own procedure. An attempt is made to evaluate the cause of the late unfavorable changes that occurred in these ears. His technique, previously described, is given briefly as consisting of three simple stages; the advantages and disadvantages are pointed out. Steffensen discusses the problem of absorption and replacement of the preserved cartilage implants by fibrous tissue. He believes that autogenous cartilage would be a better supporting structure than preserved cartilage, the junction of two ribs from the region of the seventh, eighth, and ninth ribs being required, in young adult life.

A technique is described by Converse, Nigro, Wilson, and Johnson [15] for correction of lop ears, including the two characteristic deformities of faulty development of the antihelix and excessive cupping of the concha.

The ear is folded back until a normal appearance of the antihelix curvature is attained, and an excess fold of postauricular skin is usually revealed. Corrected limits are marked off. An ellipse of skin is excised from the medial or posterior aspect of the auricle. The incised pear-shaped central segment is folded back and formed into a tube to reproduce the appearance of the antihelix. Excess cartilage from the concha and the cauda helicis is excised. Suturing of the skin under tension following operation assists in the retention of the auricle in its corrected position.

In constructing the upper half of the auricle, Adams [16] used the greater portion of the concha, with perichondrium intact on both sides, taken from the opposite ear as a substitute for the shape and size of the required cartilage. The outer rim of the concha graft serves well for the helix framework of the new ear without creating any significant change in the size and contour of the donor ear. The first operation consists of taking the cartilage of the normal ear and inserting it under the postauricular skin of the affected side. The second procedure is the separation of the upper half of the auricle from the head, and the application of a full-thickness skin graft to cover the operative defect behind the auricle and the postauricular region. In a case of left ear reconstruction by this procedure, after an interval of six months postoperatively no noticeable change was observed in the size, shape, and contour of the implanted concha graft.

In reporting one particular case in which the entire external ear was avulsed and brought in with the patient, Sexton [17] makes a plea for the use of ear cartilage. Every effort should be made to save all viable ear cartilage in a case of ear trauma, and to protect the intact ear cartilage from further trauma due to infection or exposure. Any segment of ear cartilage can be judiciously preserved by burying it in the postauricular region or in the abdomen for future use if necessary.

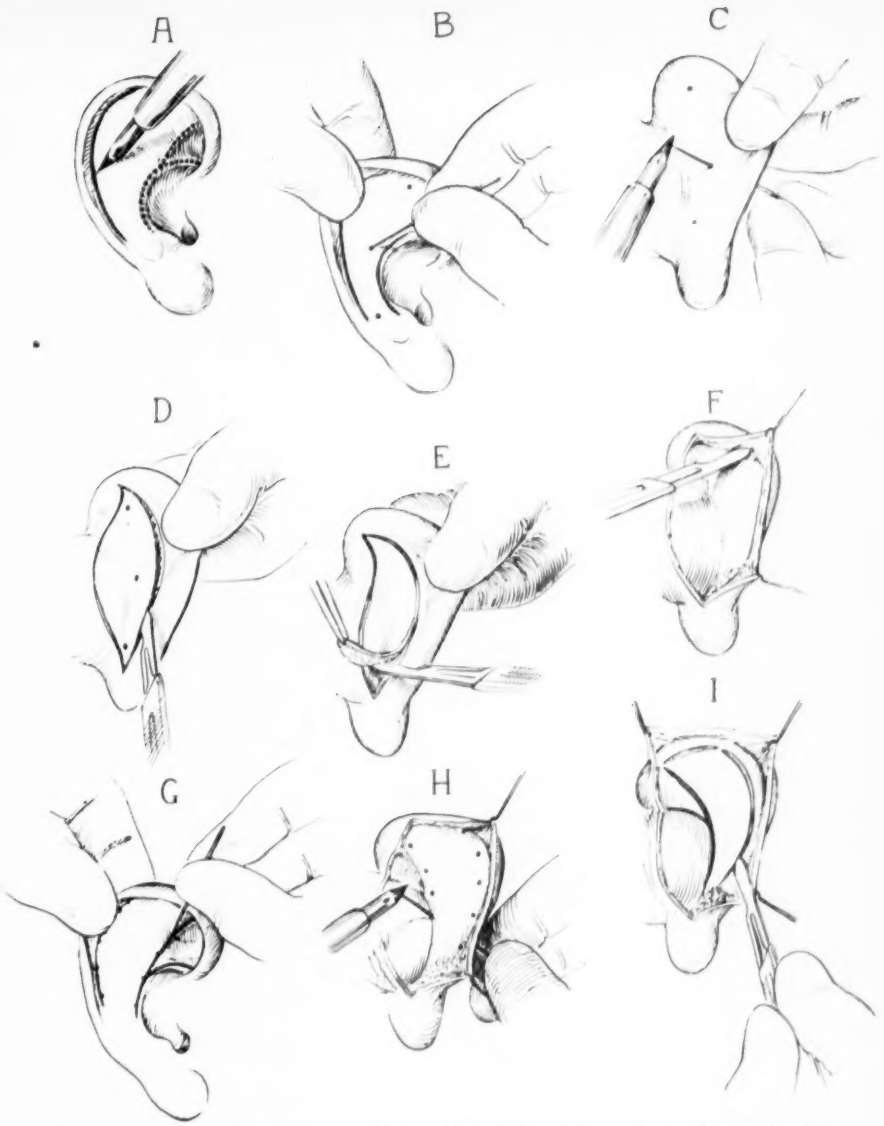


Fig. 4A.—*A*, the deformed ear has been folded back. The anterior and posterior limits of the antihelix are outlined with ink. An additional ink line outlines the crus helicis. The dotted line represents the portion that extends into the concha behind the antihelix fold.

B, a needle is placed through the center of the outlined pear-shaped area at the upper, middle, and lower portions.

C, the needle transpierces the ear and is tipped with ink in order to leave a mark upon the skin.

D, the three ink dots indicate the center of the elliptical area of skin to be removed.

E, the ellipse of skin and subcutaneous tissue is resected.

F, the skin edges are undermined in order to obtain adequate exposure of the auricular cartilage.

G, the limits of the pear-shaped segment are outlined by another series of perforations with a straight cutting needle.

H, the needle is tipped with ink in order to leave a mark upon the cartilage, indicating the outline of the pear-shaped segment.

I, incisions are made through the cartilage along the anterior and posterior limits of the pear-shaped area. Additional incisions are made, one superiorly following the curve of the helix and another through the crus helicis. Note that the incision which follows the curve of the helix superiorly does not join with the vertical incisions. (Reproduced by permission from Converse, J. M.; Nigro, A.; Wilson, F. A., and Johnson, N.: Plast. & Reconstruct. Surg. 15:413 [Fig. 2], 1955, Williams & Wilkins Company.)

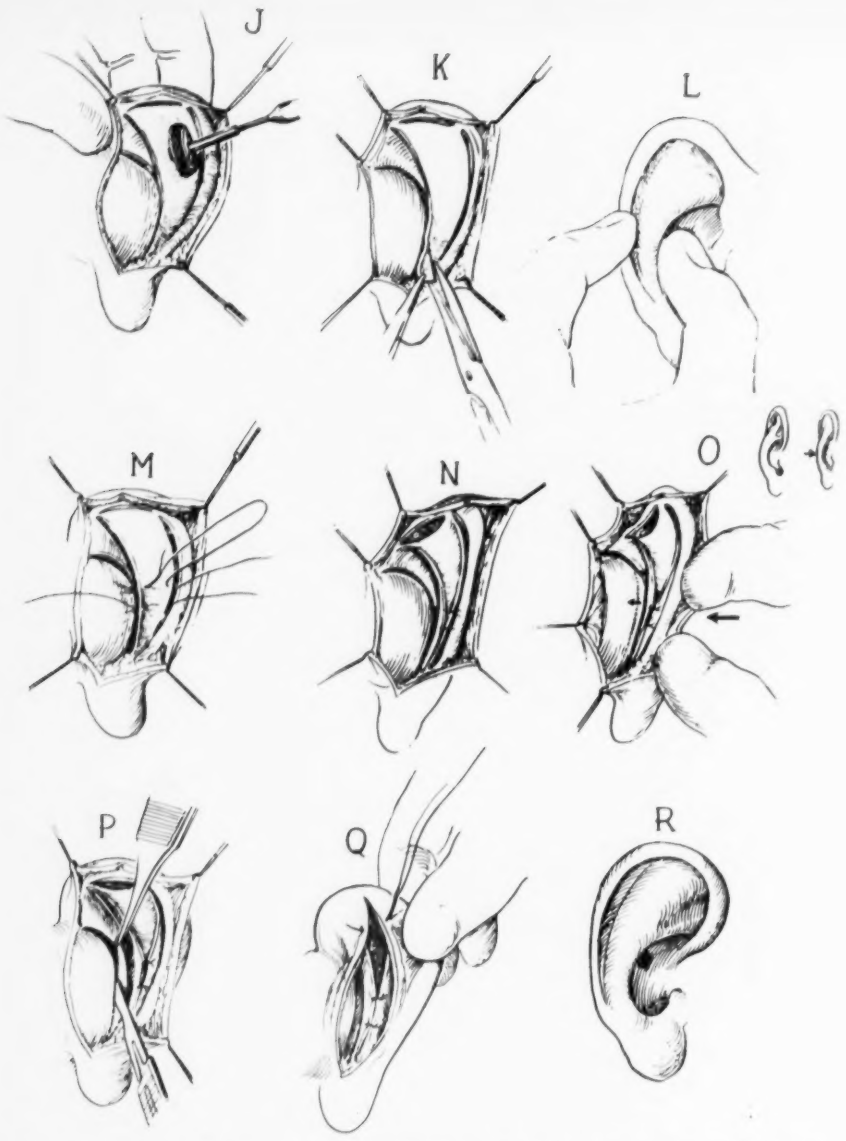


Fig. 4B.—*J*, in certain cases the auricular cartilage is thick and cannot be readily folded back. In such cases thinning of the cartilage is accomplished by means of a wire brush, electrically driven, similar to that used for abrasion of the skin.

K, in many cases resection of a portion of or of the entire cauda helicis is necessary to correct the protrusion of the lower part of the ear.

L, the auricular cartilage may now be folded back, simulating an adequate antihelix.

M, the sutures are placed in order to tube the cartilaginous pear-shaped segment.

N, a sufficient number of sutures are placed in order to produce the adequate amount of curvature.

O, in most cases there remains a protrusion of the lower half of the ear due to an excessively cupped concha. By pressing the antihelix inward it is possible to evaluate the amount of conchal cartilage to be resected to correct the protrusion.

P, an adequate segment of conchal cartilage is resected.

Q, the operation is completed by suturing the margins of the postauricular skin defect.

R, an adequately curved antihelix has been formed and excessive cupping of the concha has been corrected. (Reproduced by permission from Converse, J. M.; Nigro, A.; Wilson, F. A., and Johnson, N.: Plast. & Reconstruct. Surg. 15:414 [Fig. 2], 1955, Williams & Wilkins Company.)

Davidson[18] suggests the endaural approach or access through the mastoid for operation on the temporomandibular joint. With use of an "anterior" endaural incision, the jaw joint may be exposed for almost half its depth in addition to its aspect, and the difficulties of a deep dark cavity thus are minimized. An additional advantage lies in there being no danger to the branches of the facial nerve. The incision is really a modification of that used for endaural mastoidectomy. It begins an inch in front of and ends at the cleft between the tragus and the helix; the temporal fascia is exposed and the incision carried down to the bone. The juncture of the cartilaginous with the bony meatus is divided in the anterior meatal wall immediately behind the joint. Elevation of the soft tissues is started from the lower surface of the postglenoid tubercle. The periosteum of the zygoma is stripped as far as the articular eminence. The joint capsule is exposed, and the lower joint cavity is opened by horizontal incision through the joint capsule. The neck of the condyle is exposed by converting this horizontal incision into a T-shaped incision, and the condyle and neck are exposed. Condylectomy or meniscectomy is done according to requirement.

Nose

For any one interested in the cartilaginous structures of the nose, this article by Converse[19] is recommended for careful study.

In plastic surgical operations on the external nose, due considerations must be given to the preservation of the dynamics of the quadrangular septal cartilage, and lateral and alar cartilages. Practical terms are designated, such as septal angle, supratip area, mobile septum, and membranous septum.

Converse emphasizes some points. The lateral and septal cartilages join end to end. These cartilaginous ends are bound closely by dense connective tissue; but there is always separation, although a continuity of the perichondrium is often observed.

Straith and his colleagues[20] state: "The deviated nose continues to be one of the most difficult of all nasal deformities in which consistently good results can be assured the patient. . . . Regardless of the amount of cutting or repositioning of these parts, they are notorious for slipping back into their old shape and form."

The failure of the methods used in the treatment of deviations of the lower one-half of the nose has necessitated the development of a new technique, "pin fixation." It is hoped that this method will solve this irritating problem.

It is probably best to leave the pins in position for a minimum of 14 days, but longer than 21 days is probably unnecessary.

According to Blocksma, and Innis (of Pakistan),[21] lopping off noses was practiced in India some 3000 years before the birth of Christ. A certain Hindu caste first began reconstructing noses, chiefly from adjacent cheek flaps. During a period of five years, Blocksma and Innis have treated large numbers of women who have been punished by nose amputations for infidelity, and men who suffered such disfigurement in disputes. These mutilations are practices in certain tribal states of Pakistan.

In a series of 30 cases of nose amputations the supraorbital forehead flap proved to be the simplest, most rapid method of repair, and gave the best cosmetic results. The best method of arm tube repair involved suturing the distal end of the tube to the nasal bridge. This allows a secondary procedure of shaping of the alae and columella. Marked increase in pigmentation was observed in arm and abdominal tubes and free ear lobule grafts.

Holmes[22] describes plastic repair of the soft tissues of the nose in an 84-year-old man who had been operated on for basal-cell carcinoma. A small hole in the lateral wall was closed (by Dr. F. deQuervain) by means of a septal flap hinged along the dorsum. This method provided the lining and cartilage support, which was covered by a local skin flap. The result is gratifying functionally and cosmetically.

A lateral displacement of the bony as well as the cartilaginous parts, pyramid and septum, in the newborn, as pointed out by Kirchner,[23] cannot be corrected by repositioning in the midline even by means of instruments. The author reports three cases of this condition, two in siblings. Prenatal trauma is considered the cause of such deformity, possibly a sudden blow against the bony pelvis or, more likely, prolonged pressure of the nose against a bony prominence. Without treatment the nose assumes a midline position before the age of 3 months.

Lewin[24] presents a case of an infant of 2 months with meningococcemia associated with the Waterhouse-Friederichsen syndrome. Extensive sloughs of soft tissue developed rapidly at the height of the disease, the face being primarily involved. The face was severaly disfigured by loss of the nose and parts of the upper lip, and large defects on the cheek. Immediate skin grafting was carried out for any open wounds; the lip was repaired and the nose reconstructed. Total rhinoplasty was done before the child was a year old, with the expectation of replacement of the reconstructed nose by another one later in life.

Regarding secondary rhinoplasties, O'Connor and McGregor[25] discuss cartilage implant, tip cartilage grafts or posts, infected cartilage implants requiring secondary nasal surgery, contraction or webbing of the intranasal vestibular incision, drooped tips, recurrent nasal hump, width of the nasal base, deviation of the nasal tip, and common nasal deformities associated with cleft lips.

Lips

Webster[26] gives a good history of the literature on the procedures that have been devised for repair of upper lip defects. In the best possible repair of an upper lip defect all elements of the lip should be replaced. The author advocates lip and cheek flaps adjacent to upper lip defects for repair. These flaps can be advanced medially with minimal damage to nerve and vascular supply, and with minimal distortion and loss of function. The excision of crescent-shaped perialar tissue, with closure in the alar fold, facilitates the advancement of such flaps. If this perialar tissue is not excised, in certain instances it may be utilized to advantage in the flaps advanced.

In partial loss of the lower lip, Ashley[27] considers a V-excision with primary closure sufficient. A modified Stein-Buck-Estlander-Abbé procedure is submitted for reconstructing large defects, utilizing a full-thickness (without mucosa) flap rotated through only 90 degrees, with a separate mucosal flap. This he regards as satisfactory for the repair of defects caused by trauma and by the wide removal of certain types of advanced carcinoma of the lower lip. When large losses of the lip are to be repaired and adequate regional tissues are available, the methods of Owens, Smith, and Pierce may be efficiently completed in one stage. In total loss of the lower lip and associated structures, first the soft-tissue contour must be restored by means of distant tissues; then bone grafts, sulcus grafts, glossoplasty, etc., may be instituted.

Illustrations representing some of the commoner types of lower lip deformities and their repair are presented.

In Edwards' procedure for reconstruction of the lower lip, a bipedicled flap of skin, muscle, and mucosa from the upper lip to the lower is used, involving complete obliteration of the mouth and formation of a new mouth higher up. This is effected by inverting mucosa of the upper lip and skin of the lower reconstructed lip from the real or simulated mucocutaneous line. Three weeks later a new mouth is formed by incising through the skin, muscle, and mucosa of the upper lip. This procedure particularly applies to those cases in which the normal ratio of upper to lower lip (2:3) has been changed to 1:1 or 3:2 during the chin reconstruction.[28]

Edwards gives a single case report.

Harelip and Cleft Palate

In this article LeMesurier[29] simplifies his universally used quadrilateral flap op-

eration for repair of harelip, and brings out some points concerning the procedure on the lip itself. The operation has now been used by the author over a period of 20 years, and he finds that the general appearance of the lips seems to improve with time. With stricter attention to detail good results on the lip itself become more frequent. LeMesurier feels that improvements will be devised by others to further perfect the method, which is recognized as leading in the right direction.

May[30] reports that he has applied the principle of the LeMesurier quadrangular flap method for repair of cleft lip to the Axhausen technique, with gratifying results. A fullness of the lower fourth of the lip is obtained without sacrificing much skin. The length and adjustment of the quadrangular flap are determined and made at the end of the operation so that changes still can be made.

The procedure is carried out in the following stages: outlining of the lip incisions, formation of the floor of the nostril, correction of the alar displacement, correction of the septal displacement, and closure of the lip.

At the Indiana University Medical Center a survey of approximately 750 patients operated upon for cleft lip and cleft palate in the past 10 years is being made. In a preliminary report, Trusler, Bauer, and Tondra[31] express the belief that with good surgical correction of the deformity at the proper time the problem of additional rehabilitation is reduced to a minimum. Diagrams demonstrate modified LeMesurier techniques for repair of partial and complete cleft lip, and the Trusler-Tondra-Bauer two-stage procedure for repair of complete bilateral cleft lip. Secondary repair of an unsatisfactory unilateral cleft lip scar by the square-flap technique is shown along with techniques for other repairs.

The authors observed that the cleft lip-cleft palate surgery of the present day is not producing serious growth disturbances in the maxilla. They prefer to employ dental prosthesis for the restoration of teeth and maxillofacial contour. They have noted that in the majority of cases a good surgical repair at 18 months to 2 years of age gives good speech without specialized speech training. The patient with a marked hypoplastic palate usually does not get good speech without the help of a speech therapist, nor does the patient with a palate previously mutilated by unsuccessful surgery.

At the Allentown Cleft Palate Clinic, in cases of cleft of the lip and/or palate associated with cleft of the alveolus, as reported by Marcks, Trevaskis, and Tuerk,[32] repair of the anterior palate is carried out with use of the vomerine mucoperiosteum and nasal mucoperiosteum from the maxilla; this is accompanied by primary lip repair. Repair of the posterior palatal cleft is accomplished in stages by V-Y retropositioning of the palate with the vessels intact. Bilateral complete clefts are treated in like manner in that the lip and anterior palate on one side are repaired at one stage and six weeks to two months later the opposite lip and anterior palate are repaired. Bloc resection of the premaxilla is done only if there is marked protrusion. The best definitive treatment is resection as soon as a satisfactory prosthesis can be inserted. Orthodontic care should be undertaken as soon after birth as possible, provided a practical method can be devised.

Pierce and his colleagues[33] state that orthodontic treatment should be started early for the cleft-palate patient. When the permanent dentition is complete, it is too late to move and mold the maxilla. Between the ages of 3 and 5 years tooth movement will exert its most favorable or unfavorable influences.

As the orthodontic therapy progresses, plans of treatment may have to be changed according to the individual course of events. If orthodontic care is started at an early age, the secondary treatment is minimized.

It is evident that the palatal processes of both maxillae may be moved with relative ease in the young. As a result, the dental arch is more functional and the pos-

sibility of normal speech and a good cosmetic lip is enhanced.

Holmes and Reed [34] made a survey of 26 patients on whom an operation had been performed for cleft palate during the past 10 years, to ascertain the incidence of hearing loss. They found that 62% had a hearing loss greater than 10 db. in one or both ears. Graphs showed no definite relationship between the severity of primary deformity and hearing loss, nor between hearing loss and age of closure of the palate, the degree of flexibility of the closed palate, or the amount of nasopharyngeal occlusion. Furthermore, no relationship could be shown between the hearing loss and the presence or absence of tonsils or the presence or absence of an abnormal amount of adenoid tissue.

The authors consider careful detection and observation of the ear findings in these patients to be the only practical control over repeated infections of the middle ear, with resultant hearing loss. The importance of early treatment of even minor ear infections is emphasized.

Robinson, Byrne, and McClelland [35] report on a study (at the University of Kansas Medical Center) based on the speech analysis of 20 patients who had had a posterior pharyngeal flap operation at least two years previously. For the first 10 patients, tape recordings were studied individually and independently by three qualified speech therapists experienced with cleft-palate patients and by four graduate students of speech without such experience. The second 10 patients were studied only by two of the same qualified speech therapists and the surgeon. Criteria for judgment of nasality, volume, pitch, and articulation were set up in advance. The general effectiveness of the speech as rated by the examiner and the family's impression of the results of the operation were recorded. A surprising degree of correlation occurred in the grading.

The effectiveness of speech was average or good in five patients. Eighteen out of the twenty who had had poor speech preoperatively had understandable speech. How much surgery aided in correcting the nasality is quantitatively unknown.

Eleven out of these twenty patients had had some speech therapy, ranging from one month to three years.

Poor results from the operation were few. The velopharyngeal closure should not be considered indispensable to good speech.

In the opinion of the authors, with such a small number of patients and without preoperative evaluation, no valid conclusions can be drawn from this preliminary study.

Barton [36] describes the ridge of Passavant and reports certain laboratory observations regarding it. He comments on the importance of it as a physiological component of the nasopharyngeal sphincter.

"This structure is formed in the mucosa of the posterior pharyngeal wall as a result of the active constriction of the upper and inner horizontally disposed fibers of the superior constrictor muscle.

"The nasopharyngeal sphincter is formed by the levators pulling the palate upward and back, by the palatopharyngeus pulling lateral pharyngeal walls inward, and by the ridge of Passavant bulging anteriorly from the posterior pharyngeal wall.

"Because of its importance in articulation and deglutition, this area should be subjected to a minimum of trauma if postoperative speech and swallowing difficulties are to be avoided."

Beers and Pruzansky [37] describe the facial growth of a child on whom the Beverly Douglas procedure was carried out as a lifesaving measure. The infant had micrognathia, cleft palate, glossoptosis, and severe cyanosis. This is said to be the first reported cephalometric follow-up on an infant for whom this procedure was utilized.

The growth increments in the pharyngeal airway and in the facial profile were analyzed. The increasing adequacy of the airway and the improvement in the facial profile were clearly demonstrated by the serial records. Beers and Pruzansky recommend the operation as a valuable means of

Fig. 5.—Model illustrating surgery: (*a*) Template, indicating amount of bone to be removed to effect arbitrary postoperative position from preoperative position determined by intraoral Gothic arch tracing. (*b*) Wire loops placed prior to surgery to facilitate intermaxillary wiring during operation. (Reproduced by permission from Smith, A. E., and Robinson, M.: Plast. & Reconstruct. Surg. 15:200 [Fig. 4], 1955, Williams & Wilkins Company.)

Fig. 6.—Model illustrating surgery: (*a*) Osteotomy complete. (*b*) Location of bone division between ascending ramus and condylar fragment outlined with pencil. (Reproduced by permission from Smith, A. E., and Robinson, M.: Plast. & Reconstruct. Surg. 15:200 [Fig. 5], 1955, Williams & Wilkins Company.)

Fig. 7.—Model showing condylar fragment divided from the ascending ramus (*a*). Immediately on completion of this bone division the muscles pull the mandible posteriorly to the predetermined postoperative position. An 0.018 nonelectrolytic interosseous wire in place prior to division of condyle from ascending ramus. (Reproduced by permission from Smith, A. E., and Robinson, M.: Plast. & Reconstruct. Surg. 15:201 [Fig. 6], 1955, Williams & Wilkins Company.)

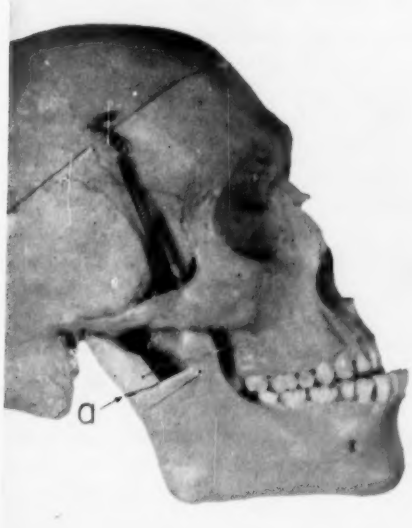
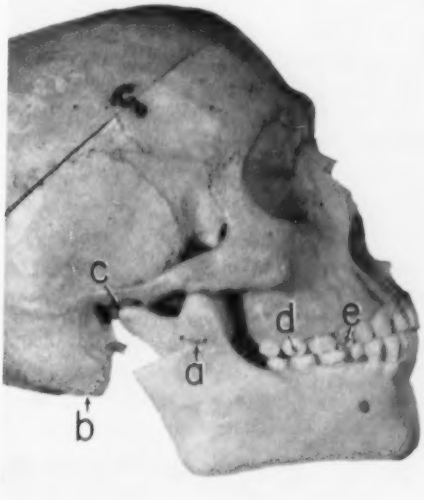


Fig. 8.—Model showing submandibular-notch ostectomy, sliding condylotomy completed. When the condyle and ascending ramus have been divided, as shown in Figure 7, the muscles pull the mandible to the new position; *a*, interosseous wire; *b*, mastoid process; *c*, condyle in original position; *d*, improved occlusion; *e*, intermaxillary wires in place for six to seven weeks during healing. (Reproduced by permission from Smith, A. E., and Robinson, M.: Plast. & Reconstruct. Surg. 15:202 [Fig. 7], 1955, Williams & Wilkins Company.)



giving relief in such respiratory embarrassment.

Jaw

Smith and Robinson[38] evaluate the results of their new technique for reconstruction of the prognathic mandible in 65 patients in whom a submandibular-notch ostectomy with sliding condylotomy was done. The incision in their procedure is made only through the skin, starting 1 cm. above the shaved hairline and 5 cm. anterior to the ear. The incision is extended backward and downward directly to the most anterior portion of the helix and then down along the anterior inner margin of the ear. The incision is ended 0.5 cm. behind the lobule. The outlined skin flap is elevated by sharp dissection adequately to expose the region lateral to the mandibular notch. That portion of the ascending ramus in the region of the mandibular notch between the coronoid process and the neck of the condyle is exposed.

The advantages of the procedure are no sacrifice of teeth or useful bone, the bone removed contains no large nerves and blood vessels, no disturbance of the muscles of the floor of the mouth, no involvement of the ligaments of the temporomandibular joint, no disturbance of the site of the ostectomy by forces of muscles of mastication, and no disturbance of tongue space and of condylar function.

In reconstruction of the temporomandibular joint, Hinds and Pleasants[39] used autogenous cartilage—the material of choice in their opinion—securing it in place with a Kirschner wire, in three patients. These patients had conditions of long standing.

After removal of the meniscus in subluxation of the temporomandibular joint, Gordon[40] slips a polyethylene cap over the head of the mandible. He also incorporates a tiny metal bead in each side of the cap because polyethylene is not opaque to roentgen rays.

In a patient with bilateral temporomandibular joint ankylosis, accompanied by mandibular retrusion, Kazanjian[41] found the cause to be disease within the joint.

In a two-stage operation arthroplasty was carried out on each temporomandibular joint by making a transverse section of bone across the ankylosed neck. The space left by removal of the bone section was filled with a fascia lata transplant.

Six years later the facial deformity was corrected. A special appliance constructed to provide immobilization is demonstrated. Bilateral mandibular osteotomy and intermaxillary wiring were done, according to Kazanjian's own procedure, previously reported.

Georgiade and his co-workers[42] report on the incidence of 36 cases of ameloblastomas of the mandible or maxilla at Duke Hospital, Durham, N. C., in the past 15 years. Some of the tumors histologically resembled the embryonic stage of the developing tooth follicle. Other tumors resembled squamous-cell carcinomas from the histologic viewpoint. The ameloblastoma is clinically and roentgenologically differentiated from other tumors similarly located, such as the giant-cell tumor and ossifying fibroma.

In patients with ameloblastomas of the mandible the treatment of choice, whenever possible, is resection of the involved area and immediate autogenous bone grafting.

In his article on fibrous dysplasia of the mandible, Lewin[43] points out that the histologic structure varies a great deal, depending on the prevalence of fibrous or osseous elements, cellularity and pattern of the connective tissue, extent of calcification, presence or absence of hemorrhages and giant cells, formation of cysts, and the like. The craniofacial skeleton is a frequent site of this disease. These tumors do not metastasize and enlarge by direct extension, nor do they infiltrate their surroundings. There is a great variation in rapidity and pattern of growth.

Occasionally, after becoming stationary, the lesion may regress. It is only when the conservative approach proves ineffective

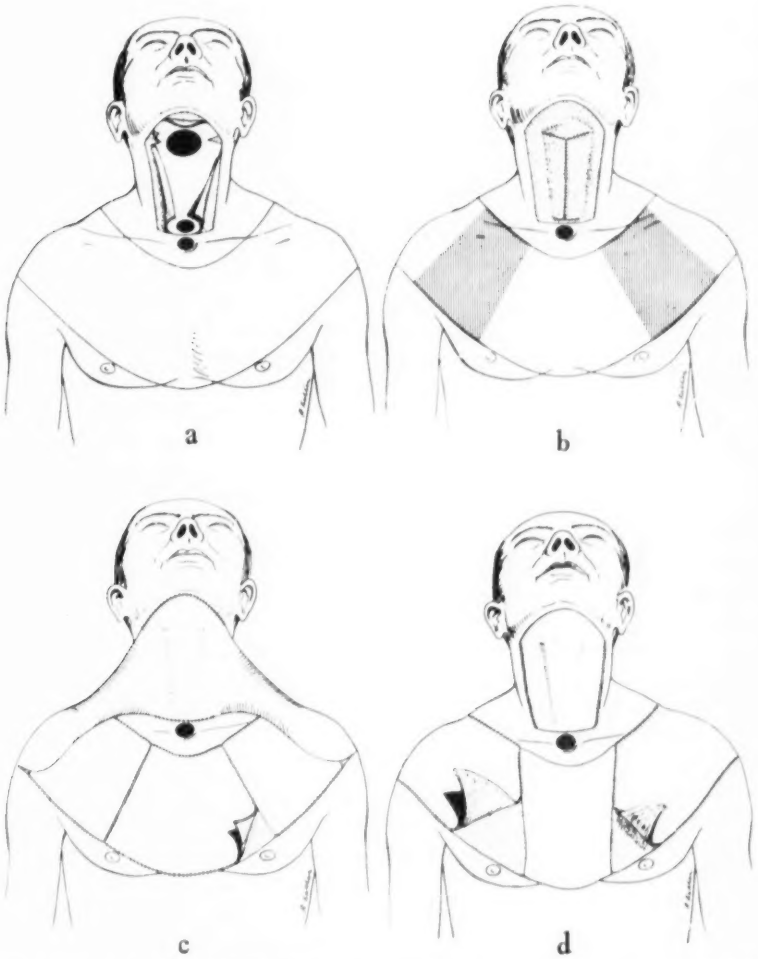


Fig. 9—(*a, b, c, d*) Stages of reconstruction utilizing turnover flaps of cervical skin for lining and bipedicle acromiothoracic flap for covering of the new pharynx. (Reproduced by permission from Ashley, F. L.; Briggs, J. D., and Afflley, H. U.: Plast. & Reconstruct. Surg. 16:371 [Fig. 19], 1955, Williams & Wilkins Company.)

that a radical resection should be considered.

The present concept of fibrous dysplasia as a benign tumor originating in a mesenchymal defect seems to be the most acceptable explanation.

Ragnell and Hillerström [44] present three interesting cases involving the jaw. These cases were characterized by peculiar pathologic conditions that necessitated original surgical measures and prosthetic devices for the postoperative fixation. Recurring adamantinoma was excised, followed by iliac bone graft. In extreme anomaly of the jaw and midface deformity, transverse osteotomy of the mandibular ramus was followed by reconstruction by bone chips and nasal block bone graft. Osteotomies of the ramus, and at the midline of the mandible in two stages in the third case, were carried out, and repositioning was by cap splints.

Esophagus and Pharynx

Four major methods of pharyngeal reconstruction with modifications are presented by Ashley, Briggs, and Affley.[45] The primary closure technique is the simplest and most efficient and is completed in one stage. If the remaining pharyngeal mucosa is insufficient, a skin graft must be used to bridge the defect and to provide an adequate lining. This method, however, is dependent on the salvage of adequate covering from the adjacent skin and subcutaneous tissues. Stricture at the junction of the graft and the esophagus often occurs postoperatively, and dilation by the retrograde route is required.

Available local and distant tissue was utilized in four patients. In one patient mucosal tissue was employed for reestablishing continuity of the hypopharynx through a Kaslow nasogastric tube, followed by feeding gastrostomy. In the second patient a split-thickness skin graft was sutured as lining of a tantalum mesh stent, joined to the oropharynx above the esophagus below. Closure by overlapping sternocleidomastoid muscles was covered by cervical skin. Skin flaps formed the new tracheostoma. In the third patient the pharyngeal defect was closed with an acromiothoracic tube for covering and lining. In the fourth patient turnover flaps of cervical skin were used for lining, and a new pharynx was covered with a bipedicled acromiothoracic flap.

The authors feel that reconstructive methods utilizing some form of flap or tube from a more distant location give better cosmetic and functional results. But multiple stages, and consequently more hospitalization, are required. Occasionally this can be lessened by careful planning and a short stay for each procedure.

In a case reported by Hardin,[46] previous laryngectomy because of a squamous-cell carcinoma was followed by tracheostomy, and later a bilateral supraomohyoid neck dissection was done for recurrence. Four years later extension of the lesion through the upper pharyngoesophageal mucosa, also pathologically reported as squamous-cell carcinoma, was treated by radical excision. After a right lateral pharnygotomy and bloc dissection of the lymph nodes, reconstruction was carried out with a lateral cervical flap, which failed because of circulatory embarrassment. It was then decided to provide coverage of the surgical pharyngoesophageal defect by means of a bipedicled arm flap.

For reconstruction of the cervical esophagus following radical surgery for cancer, the author feels that the use of such an arm flap provides a direct and rapid means of tissue transfer in the reconstruction of pharyngoesophageal defects. Fixation of the arm to the head by a cast did not result in any limitation of shoulder motion.

A patient with nasopharyngeal chordoma associated with marked destruction and distortion of the face, as reported by Crikelair and McDonald,[47] received palliative surgery and irradiation therapy, with much improvement. The chordoma is regarded as "a normal growth" of notochord tissue "in an abnormal position" (Williams).

Fracture

The use of multiple wire pins, after reduction, at the hands of Fryer and Brown,[48] has given adequate fixation in fractures of the face and jaw. This measure has been employed with other methods of immobilization. Solid union has resulted in severe compound facial injuries or crushes, and subsequent bone graft as well as use of expensive, complicated, cumbersome apparatus for traction or external forms of unsteady fixation have been avoided. It is very difficult to reduce fractures of the facial bones after a lapse of more than 10 days following injury.

Minimal débridement of facial wounds is done to preserve features. Soft-tissue lacerations and tears are carefully closed with fine sutures close to the edge of the wound. Complicated fractures of the mandible can be stabilized, after reduction, by this method of internal wire pins driven across the fracture sites. They are also used to afford

additional support in the fixation of complicated middle facial fractures, and of transverse fracture of the maxilla or those extending up into the orbit.

O'Connor and McGregor[49] prefer an adequate, conservative débridement of contaminated facial wounds, with reduction and immobilization of fractures. This is followed by immediate primary closure. Their technique has given good results.

It is the belief of Stuteville and Lanfranchi[50] that extracapsular fractures of the condyle in which the head has been torn from the capsule and displaced medially should be treated by open reduction and the replacement of the condyle into its normal anatomic relationship.

Through a preauricular incision the skin over the tragus and the parotid area was undermined and reflected; the fracture was exposed through the parotid gland. A four-hole metal condyle plate was placed across the fracture line, and the bony parts of the fracture were held together by screws.

In certain conditions it is often necessary to reconstruct the joint completely by means of a bone graft, cartilage graft, or prosthetic implant.

Priestland[51] describes a method which is employed on patients in whom sectional cap splints have been provided to teeth standing on both anterior and posterior fragments and considerable displacement has resulted from the fracture.

"Attached to the localization plates normally provided for the fixation of a screw connecting bar, two wires or 'bars' are contoured to emerge from between the lips at the level of the lipline. Depending on whether the fragments should be separated or approximated, the 'bars' should either cross or not. Rubber ligatures are then placed between the ends of the 'bars' to reduce the displacement."

In a reported case, "crossed bars" have proved most useful in reducing the inward displacement of a posterior fragment with a fracture in the "cheek teeth" area.

Priestland points out certain conditions that should prevail at final adjustment of the extraoral bars, and indications for their use.

In the technique employed by Rubin[52] for zygomatic fractures involving the floor of the orbit, the antrum on the affected side is entered as in a typical Caldwell-Luc procedure for radical antrum surgery. There is one exception, namely, all the tissues overlying the anterior surface of the maxilla and the zygoma, including the periosteum, are elevated up to the inferior orbital margin, with good exposure. A portion of the anterior wall of the antrum, about 2 cm. in diameter, is then removed. A small hole is drilled through the most lateral portion of the anterior wall. Stainless steel wire is threaded through this opening which passes through the zygoma. Fracture of the malar bone is reduced by elevation forward and upward, with controlled leverage, and fracture of the zygoma, by downward pressure. Fixation is obtained by looping wire around incisor teeth. Any remaining deformity may be corrected by a subperiosteal bone graft along the floor of the orbit.

Four illustrative cases are reported.

Tumors

A total of 42 consecutive patients with 52 capillary hemangiomas involving the face, neck, scalp, extremities, or trunk were examined in follow-up observations by Modlin.[53] He believes in spontaneous disappearance of the lesion and reports that 31 of these hemangiomas received no treatment of any kind. Complete regression occurred in 24 (61%).

In discussion of this report, Dr. David W. Robinson expressed the opinion that in some instances treatment should be done early. While a lesion may appear quite benign, later on it may prove disfiguring. He showed two slides to demonstrate how much worse a port-wine stain in childhood became at a later date. He pointed out that one cannot always be positive of the pathogenesis of this lesion. He uses this impressive study to advantage in dealing with parents whose child shows a rapid increase in a pin-sized lesion present in infancy.

Reeh and Hyman[54] advise surgical treatment as the primary method for tumors of the eyelid or in reconstruction after radiotherapy of extensive and malignant involvement. An elliptical incision and immediate closure, a full-thickness graft taken from the upper lid, a winged V-plasty, or rectangular excision and closure may be used according to location or size of the lesion or tissue involved. The method which will completely destroy the tumor with the least amount of functional impairment and the best cosmetic effect is selected.

It is thought that a spine-like bony prominence of the angle of the mandible may play a role in the causation of benign masseteric hypertrophy. This spine-like projection was present in all six patients with a mass in the parotid region referred to by Masters, Georgiade, and Pickrell.[55] They discuss the anatomy and pathology and advocate Adams' method of excision of the hypertrophied muscle tissue from the medial aspect of the masseter muscle after freeing its attachment to the inferior border of the mandible. Injury to the facial nerve and the parotid duct is less likely, and resection of any bony prominence at the angle of the mandible is adequate.

Blocker, Lewis, and Snyder[56] concur in the general feeling that every tumor of the parotid gland should be removed surgically as early as possible because of the danger of faulty diagnosis in early malignancies. They are opposed to biopsy in primary tumors which are completely or partially encapsulated. This is because it is technically difficult to excise an unencapsulated mass completely without destruction of the nerve and in many instances impossible without violation of the principle that cancers in general should be removed by dissecting around them and not disturbing the malignant tissue.

The plan of management is to approach every tumor as thought it were benign except for malignancies which are obvious because of hardness, fixation, involvement of adjacent structures, or seventh-nerve paralysis. Blocker and his colleagues believe that a combination of conservative surgery and interstitial irradiation by the rolled flap technique offers better results in the majority of lesions than radical extirpation alone or in conjunction with external irradiation. If a branch of the facial nerve is intimately involved in a well-demarcated mass, it should be sacrificed.

Four cases of rhinophyma which demonstrate the essential points of surgical management are presented by Rees.[57] In two patients the rhinophyma was associated with basal-cell carcinoma, as proved pathologically. This, in Rees' opinion, argues for surgical excision as the treatment of choice. In fact, this association of the disease and carcinoma emphasizes the advisability of treatment of all patients with rhinophyma.

Farina and his colleagues[58] describe gangrenous stomatitis as a disease characterized by an area of gangrene which spread rapidly without tendency to self-limitation and is usually associated with an extraordinarily poor condition of the patient, ocurring, as a rule, after an acute infectious disease and involving almost invariably all the tissues of the mouth. Wide excision without preoccupation for any resultant deformity is the treatment of choice imposed by this condition.

Morphologically more or less extensive losses, both of soft tissues and osseous and cartilaginous framework of the face, are observed. It is very common for the destruction to reach the lower lid, the corresponding half of the ala of the nose, the upper and the lower lip, and, very often, the maxilla and mandible. In these severer cases there is a deformity of the alveolar ridge with abnormal placement of the corresponding teeth. In some cases there is also a loss of substance of the mandible, with sequestration and subsequent deviation.

In a case of carcinoma of the epiglottis, surgery was carried out, as reported by Connelly,[59] after roentgenotherapy followed by necrosis of the epiglottis and larynx.

Cervical reconstruction was by means of a skin-lined pedicled flap.

A case of carcinoma of the sweat glands occurring on the sole of the foot is reported by O'Brien and his colleagues.[60] Despite repeated excisions, local invasion made necessary amputation of the leg at the mid-third.

As discussed by Crawford, Maguire, Georgiade, and Pickrell,[61] in all instances the development of dermoid cysts comes from a minute amount of ectoderm becoming trapped in early fetal development. Early surgical excision is regarded as the most likely means of permanent cure with the least residual deformity. In five of the seven cases presented by the authors the lesions were discovered between the ages of 2 months and 7 years. There was recurrence in two of the cases. The total number of cases reported in American and British literature is now 72.

Implants

In a panel discussion on implants in nasal plastic surgery, Converse, Becker, and Peer [62] agree that autogenous tissue is the best graft to use and is assured of good survival after transplantation. Foreign substances such as metals and acrylics or non-living tissue as a homograft are not favored. That there is always the possibility of absorption is stressed by Becker. Converse points out that tolerance of foreign materials varies according to position of the implant in the body. Preserved homograft such as cartilage is valuable when large amounts are required, in Peer's opinion.

Dencer [63] considers methyl methacrylate to have much merit as an implant for reconstructing the nasal bridge. An acrylic implant of original shape and design was used in 38 patients over a period of five years.

Technically, the only satisfactory method of approach at implantation is by detaching the columella from the lip and hinging it upward. A pocket is created in the septum if there is no septal cartilage left. The implant should not be allowed to project between the domes of the alar cartilages.

Three failures are recorded in the series of cases.

Callahan [64] reports on the use of 199 motility implants, the integrated implants imparting better motility than the buried type; the latter is more insecure. Of 343 spherical implants of methyl methacrylate emplaced beneath Tenon's capsule and the conjunctiva, there were seven extrusions. The conjunctiva and Tenon's capsule are held securely at the margin of the implant face with a permanent clamp or nylon suture.

Rubin and Walden [65] review the literature on the use of polyethylene in branches of surgery and report a series of 135 cases of reconstruction with polyethylene about the face over a period of seven years. Superior results were achieved in most patients. The authors believe that polyethylene has various advantages although it is not a body tissue.

In an experimental study by Struthers,[66] polyvinyl sponge, either alone or with transplanted bone, was implanted in contact with skeletal tissues in nine young dogs. These implants were imbedded in the periosteal bed of ribs, within cancellous bone of the sternum, and in the rectum abdominis muscle. No surgical wounds failed to heal over the implants, and no extrusion of the implant occurred.

New bone will grow about and within polyvinyl sponge from skeletal tissues within 4 weeks but does not completely infiltrate the sponge during a period of at least 20 weeks. The growth of the bone occurs most consistently from adjacent cancellous bony surfaces and is increased by the addition of autogenous bone to the implant of sponge.

In Struthers' opinion, the use of polyvinyl sponge is justifiable as a substitute for bone or soft tissue that becomes firmly fixed to skeletal tissue, depending on the nature of bony growth about and within the sponge.

In Schultz's opinion,[67] the tolerance of tantalum by the human body is better than that of any other foreign material. Over a

period of 10 years he has used it for stabilization in facial paralysis, with good results.

Tantalum monofilament wire has been used by Schultz in many patients for skin closure, also with good results. In his experience, it has not been necessary to remove the tantalum, nor has there been a tissue reaction or pain.

15 Washington St. (2).

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Audiology

Summaries of the Bibliographic Material Available in the Field of Audiology for 1955

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Introduction

This review of the audiological literature for 1955 is divided into four parts. The first section discusses primarily anatomically and physiologically oriented studies of the hearing mechanism. In the second section psychoacoustic studies pertinent to audiology are considered. The third section deals with the literature on various aspects of hearing impairment, an area we have chosen to call "applied audiology." The fourth and final section briefly considers new books and journals of 1955.

The review of the literature in these four areas is by no means exhaustive. Our aim has been to present a reasonably balanced picture of the nature and direction of activities in the field during 1955. Certain topics of interest to a number of audiologists are, for various reasons, not included. In the first two sections, for example, we have attempted to limit the coverage to those papers of primary interest to the audiologist. Although the third section attempts a reasonably complete coverage, the areas of fenestration surgery and stapes mobilization are not considered because of their excellent coverage in other reviews of this Journal.

Experimental Study of the Hearing Mechanism

Experimental studies of the middle-ear mechanism, in 1955, reflect the recent trend toward renewed interest in the action of the intra-aural muscles. A contributing factor is undoubtedly the series of recent papers by Metz, Jepsen, Thomsen, and others on the clinical utilization of the acoustic impedance bridge.

Wever and Vernon [1] attempted to delimit the threshold sensitivity of both the tensor tympani and stapedius muscles. Using visual, strain-gauge, and cochlear-potential observations, they determined the sound pressure level required to produce a just-detectable contraction of each muscle in the cat. The reflex thresholds for the two muscles were essentially equivalent and could be evoked equally well by either ipsilateral or contralateral stimulation. Noting that the reflexes are elicited only when the sound intensity is dangerously high, these investigators conclude that they are intended to perform an emergency function in protecting the structures of the inner ear from excessive stimulation. They caution, therefore, against the indiscriminate use of these reflexes as a means of measuring auditory function in animals.

In a closely allied study, Wever and Vernon [2] investigated changes in sound transmission resulting from intra-aural reflex contraction. The primary effect observed was a noticeable reduction in the transmission of low frequencies up to about 600 cps. In the range from 600-1000 cps there was some increase in transmission, while for high frequencies little effect was noted. Again, the two muscles behaved in very similar fashion, and results illustrated the protective function of these reflexes in regulating the magnitude of stimulation reaching the sensory structures of the cochlea.

Accepted for publication Feb. 18, 1957.

Palva and Ojala[3] measured bone-conduction thresholds in 42 ears with catarrhal or purulent otitis media, both before and after myringotomy, aspiration of the tympanic cavity, and healing. Although the majority of ears showed normal bone thresholds throughout the tests, a minority showed impaired bone thresholds before myringotomy, with improvement after healing. Interpreting the initially lowered bone thresholds as due to impaired mobility at the oval and round window, it was concluded that, in adhesive otitis, bone-conduction threshold losses are not necessarily indicative of sensorineural impairment.

Benson and Eldredge[4] studied the effect of five conditions of eardrum abnormality on the difference between the sound pressure measured in front of the tympanic membrane and in a speculum coupling an acoustic source to the ear canal of guinea pigs. When results were plotted in terms of the difference between the two measures as functions of frequency, quite different curves were obtained for each of the five conditions of abnormality.

Experimental study of the inner-ear mechanism continued in several traditional patterns during 1955. Wever and Lawrence[5] used cochlear potentials to measure the injury produced by overstimulation of guinea-pig ears by pure tones. Changes in the cochlear potential were found to be generally independent of frequency, but reduction in the maximum potential was greatest for low frequencies. The maximum response was affected much less than the sensitivity.

Histological studies by Bernabei,[6] Alexander and Githler,[7] and Haruo[8] both confirmed and supplemented earlier studies on the anatomical changes resulting from excessive stimulation of animal ears. Of special interest was Haruo's observations that the destructive changes induced by repeated explosive sounds were greater in sleeping or anesthetized animals than in conscious animals. Haruo attributed this difference to lack of reflex contraction of the intra-aural muscles in the sleeping state.

Alexander et al.[9] used two common methods for measuring sensitivity loss in animals after mechanical injury to the guinea-pig cochlea, and then compared the results obtained by each method with histological findings. Results showed that the sensitivity loss measured behaviorally was more closely related to histological findings than was the sensitivity loss based on measurement of the electrical response of the cochlea.

In addition to studies of the ear after experimental injury, investigators continued to contribute valuable information on the pathological anatomy of the inner ear in various forms of hearing loss. Schuknecht,[10] after studying the ears of several cats and humans with high-frequency losses, concluded that there are two types of presbycusis. One of these, considered to be a manifestation of the aging process affecting all tissues, is called "epithelial atrophy." It is characterized by widespread degenerative changes within the cochlear duct and accounts for the classic presbycusic audiogram. The second type, called "neural atrophy," involves degeneration of the spiral ganglion cells and neurons of the higher auditory pathways. Schuknecht feels that this second type is a manifestation of an aging process involving the central nervous system and accounts for the unusually severe discrimination problem so often observed in the elderly.

The functional examination represents still another approach to the experimental study of the inner ear. Waltner[11] reported findings in a subject who developed a severe bilateral sensorineural loss after ingestion of 200 acetylsalicylic acid (aspirin) tablets over a six-day period. Recruitment, recurrent tinnitus, and recurrent sensation of unsteadiness were observed. Waltner suggests increased intralabyrinthine fluid pressure with immobilization of both windows and inactivation of the external hair cells as factors explaining the observed results. Ciurlo and Ottoboni[12] report audiometric and vestibular examinations in 50 persons with chronic lead poisoning. Vestibular dis-

turbances were negligible, but slowly progressive high-frequency hearing losses were commonly found.

Lundborg [13] reviewed audiometric findings in eight cases of low-frequency sensorineural loss. Noting that auditory tests indicate that the lesion in this audiometric configuration may be either cochlear or retrocochlear, Lundborg concludes that low-frequency sensorineural loss, per se, does not indicate any particular lesion.

Békésy continued, during 1955, his extremely interesting observations on mechanical models of the cochlear partition. By sinusoidal stimulation of various sections of a model, Békésy [14] was able to demonstrate traveling waves whose direction of travel was independent of the location of the driving source. Békésy suggests that this independence explains why the sound sensation is the same whether the vibration is applied to the stapes directly (air conduction) or to the bony walls of the capsule (bone conduction).

Békésy [15] further noted that, if the skin of the arm was placed in contact with the membrane of a model, driving frequencies in the range from 40 to 160 cps could be sharply localized in narrow sections of the membrane. Localization along the membrane was practically instantaneous and was sharply defined whether the driving frequency was continuous or only two complete cycles in length. An explanation of the sharp localization perceived despite the relatively flat distribution of vibrations along the membrane is formulated in terms of inhibitory effects of the skin.

A study of the auditory threshold in the cat, by Neff and Hind,[16] showed that the upper limit of the cat's hearing is about 60,000 cps. In comparison with man, the cat may be slightly less sensitive for frequencies below 500 cps, about the same in the range from 500–4000 cps, but definitely more sensitive at higher frequencies.

Psychoacoustics

Psychoacoustic research continues to contribute valuable information to the audiologist. While the familiar problems of pitch, loudness, masking, thresholds, perception of speech, localization, etc., were pursued vigorously, during 1955, considerable attention was devoted to one particular area: fatigue and adaptation. The unusual degree of recent interest in this area is probably due to the increasing concern, among both industrial and military groups, for protecting the hearing of personnel working in high levels of noise. In any event, the number of papers concerned with problems of fatigue and adaptation in 1955 was almost double the number devoted to any other single area of psychoacoustics.

Fatigue and Adaptation.—One of the commonest methods used in the study of auditory fatigue is to expose the ear to an intense, or "fatiguing," stimulus for a brief period, and then plot the recovery of the auditory threshold after the fatiguing stimulus is turned off. Hirsh and Bilger [17] used this method to study threshold recovery for pure tones after exposure to pure tones of different duration and intensity. Preliminary results confirmed Reger's earlier report that temporary hearing loss may be greater after stimulation by a tone 20 db. above threshold than by a tone 80 db. above threshold. Further investigation, however, suggested the existence of not one but two distinct recovery processes: one rapid, the other considerably slower and more gradual. Results indicated that the slow recovery followed exposure at all levels, while the rapid recovery only occurred when the exposure tone was at or above a sensation level of 60 db. These findings led Hirsh and Bilger to suggest that the apparently greater threshold shift after exposure at 20 db. than after exposure at 80 db. was due to lack of the rapid recovery process after the 20 db. exposure. Since a number of investigators have long felt that many aspects of the fatigue problem could not be satisfactorily explained without assuming the existence of more than one underlying recovery process, these findings by Hirsh and Bilger represent an important forward

step in our attempts to understand how the ear behaves under acoustic stress.

Lierle and Reger [18] continued their very provocative research on auditory fatigue in the hearing impaired, using a Békésy-type audiometer to record threshold sensitivity as a function of time, before and after exposure at very low sensation levels. In one experiment they found that, contrary to the belief of many respected investigators, ears with end-organ pathology could not be differentiated from normal ears on the basis of the temporary threshold shift resulting from a one-minute exposure at a sensation level of 20 db. In a second study Lierle and Reger investigated the effect of subthreshold exposures on the threshold sensitivity of subjects with severe hearing loss. They were unable to detect a significant postexposure change. In a third experiment, an extremely interesting effect was noted. When subjects were required to simply trace their thresholds for a fixed frequency over a 20-minute period, the successive threshold exposures had little effect on the thresholds of two subjects with end-organ impairment but had a marked effect on the threshold sensitivity of one subject with a subsequently confirmed eighth nerve tumor. In this latter case the subject rapidly required more and more intensity to maintain the tone at threshold over the 20-minute tracing period. Kos [19] reported a similar result. Since this is exactly opposite to the outcome that many would have expected, these findings clearly define an area of extremely interesting and profitable future research.

Lightfoot [20] both confirmed and extended many previous findings in auditory fatigue. Recovery functions were obtained twice for each of 24 subjects under four conditions of exposure. While subjects showed the usual individual differences in degree of both initial threshold shift and recovery rate, they tended to remain in the same rank order throughout the postexposure period. Of particular theoretical interest was the finding that a low positive relationship existed among the subject's threshold shifts under the four different conditions of exposure. The correlation was best for threshold shifts measured three minutes after exposure. Finally, mean recovery functions showed the secondary maximum, or "bounce," previously observed by Hirsh and Ward.

Two Polish investigators, Jankowski and Iwankiewicz,[21] studied the effect of acute oxygen deficiency on the temporary threshold shift. Results indicated that, under the oxygen deficient condition, initial shift was greater and recovery rate was slower than under the normal condition.

Jerger [22] studied the effect produced on the threshold shift by varying the durations of the short tones used to trace threshold recovery. He exposed normal ears to intense white noise for two minutes, and then measured the threshold shifts for 4000-cps short tones of 500, 50, and 5 milliseconds' duration. Results indicated a disturbance of the time-intensity relationship at threshold during the postexposure period. Thirty seconds after termination of the noise, the preexposure intensity differential among these three short-tone durations was markedly reduced. As postexposure time increased, the decline in the degree of temporary hearing loss was accompanied by a gradual return to the preexposure time-intensity relationship.

Harris [23] called attention to a finding that may prove to be of practical significance in protecting the hearing of ears exposed to loud noises. Harris first measured threshold recovery in the usual way. As soon as the threshold had returned to normal, however, he reintroduced the initial exposure and measured recovery a second time. Results showed that recovery was longer after the second fatiguing period than after the first. Harris suggests that this evidence for "latent damage" may have implications for the management of personnel working in high levels of noise. He suggests that perhaps ". . . work periods should be set not only to allow the ear to recover to normal by

audiometric test, but to provide, in addition, a time interval sufficient for the effects of latent damage to be dissipated."

A series of papers by Egan and his associates at Indiana dissected the phenomenon of "perstimulatory fatigue," or "adaptation," first described in the now classic monograph by Hood.

Using Hood's basic technique, Egan [24] first attempted to determine whether the median-plane-localization process required by Hood's method was critical to the demonstration of the phenomenon. The fact that the same amount of adaptation was measured whether the tones presented to the two ears were identical or slightly different in frequency led Egan to answer this question negatively. In view of the apparently marked decrease in the ear's response to a sustained stimulus, Egan [25] next sought to determine whether the length of time a white noise was left on had any effect on the extent to which it would mask a pure tone. Again results were negative. The masked threshold was found to be independent of the duration of the masking sound. In a third study Egan and Thwing [26] compared adaptation measurements obtained by three different methods. These results showed that the actual decrease in loudness during the adapting period was less than the results of the median-plane-localization method would indicate. This finding led Egan and Thwing to suggest that the process of centering the sound image in the median plane might involve changes in aspects of the excitation pattern other than loudness, per se.

In closely allied studies Carterette [27] measured adaptation for both continuous and interrupted white noise, while Thwing [28] investigated the spread of adaptation of a pure tone to neighboring frequencies. Of particular interest was Carterette's finding that measurable adaptation could be demonstrated if the noise was interrupted at a sufficiently rapid rate. Carterette's data constitute a valuable point of reference for anyone who contemplates the use of repetitive stimuli in auditory experiments.

Tanner [29] compared adaptation and "fatigue" as measured in the conventional threshold-shift sense and found a negative relationship, suggesting the possibility that adaptation serves a protective function in reducing the possible noxious effects of continued stimulation.

Pitch.—Research on this basic attribute of sound continues to stimulate interest because of its important implications for theories of hearing.

In studying the pitch characteristics of pulsed tones, Thurlow and Small [30] found that when the carrier frequency was 1000 cps the pitch corresponded, not to the carrier frequency, but to the rate at which the tone was pulsed. When the carrier frequency was 5000 cps both low and high pitches were heard, although spectral analysis failed to reveal energy at the frequency of the pulse rate.

Small [31] subsequently studied the influence of various parameters on the pitch of amplitude-modulated signals. Again two pitches could be identified—one corresponding to the modulation rate, the other corresponding to the carrier frequency. Results indicated that the perception of the pitch corresponding to modulation rate depends on the band width and spectral location of the frequency components of the pulsed signal. The envelope wave form was also noted to be a contributing factor.

Fresh observations on diplacusis were contributed by both Ward and Berendes. Ward [32] reported extensive observations on two extremely interesting cases in which low-intensity pure tones in the 3000-4000 cps range were heard as several distinct pitches. The various tones heard in addition to the tone presented corresponded to the combination tones that would be expected in a normal ear stimulated by two tones simultaneously. An explanation is formulated in terms of a defective "peaking" process in the cochlea.

Berendes [33] emphasizes that, in subjects with hearing loss, the diplacusic disturbance involves a more complex change than a simple shift in the subjective pitch. The

pure tone is often perceived with a "noisy character," suggesting not only a shift in the site of maximal stimulation but a wider area of excitation on the basilar membrane.

Loudness.—One of the more important developments in the area of loudness during the past decade occurred in 1955 with the publication of Stevens' revised loudness scale.[34] After an exhaustive review of all the available evidence, Stevens concluded that the relationship between loudness and intensity for a 1000-cps tone could be expressed in extremely simple terms. Over virtually the entire range of audible intensities, a 2:1 loudness ratio is produced by an intensity difference of 10 db. The specific equation for the new scale is

$$\log L = 0.03\,N - 1.2$$

where

L = loudness in sones

N = loudness in decibels

In other words, if the intensity is increased by 10 db., the loudness will be doubled. Conversely, if the intensity is reduced by 10 db., the loudness will be halved.

In a closely related investigation Poulton and Stevens[35] measured the intensity changes necessary to halve and to double the loudness of white noise at various sound pressure levels. An important aspect of their procedure was the use of the sone potentiometer, an intensity control whose angular turn is proportional to the change in loudness. Results showed that, for white noise, the median decibel changes required for 2:1 loudness ratios varied from 6 to 10 db. over the range of sound pressures studied.

In still another closely related study Stevens, Rogers, and Herrnstein[36] duplicated the earlier study of Laird, Taylor, and Willie in an attempt to determine why these investigators obtained a value of approximately 20 db. as the reduction in intensity required for half loudness, a value in sharp disagreement with the results of other investigations. Results indicated that the procedure employed by Laird, Taylor, and Willie was probably "overly sensitive to the range and order of presentation of the comparison stimuli" and that, if precautions were taken to avoid these possible sources of bias, the customary value of 10 db. for half loudness was obtained.

Continuing his ingeniously conceived studies of differential intensity sensitivity, Pollack[37] compared the accuracy of discrimination under conditions of short (five seconds) and long (one-half to three days) time intervals between the two stimuli to be compared. "Long-time" sensitivity was found to be surprisingly good. Expressed in decibels, the long-time differential threshold was only twice the short-time threshold.

In a related experiment Pollack[38] modified the conventional method of constant stimulus differences by holding the intensity differential between the reference and the comparison signals constant while varying both the frequency and intensity of successive reference signals. The accuracy with which subjects were able to respond to the fixed difference between the reference and comparison signals declined as a function of (1) the magnitude of the intensity difference between two reference conditions, (2) the frequency with which shifts between the two reference conditions occurred, (3) the time interval between successive stimulus pairs, (4) variation in frequency of the reference signals, and (5) the probability that a given reference signal would occur in each pair. In evaluating these results Pollack takes special note of the extent to which these shifts in discrimination are apparently out of the subject's control. Thus, the situation is considerably more "stimulus-bound" than had been heretofore presumed.

Perception of Speech.—In view of the increasing use of speech signals as stimuli in auditory tests (nonsense syllables, spondees, PB monosyllables, continuous discourse, etc.), the systematic study of parameters affecting the perception of speech constitutes a valuable source of basic information for the audiologist. Too often, however, he has failed to take advantage of research findings in this area.

The following three papers illustrate studies which, although directed toward "basic" problems, relate closely to the design and use of speech tests in the evaluation of hearing impairment.

Miller and Nicely [39] attempted to analyze the nature and pattern of the errors made when listeners were required to identify consonant sounds heard over a communication system containing both frequency distortion and a masking noise. Each consonant was presented several times. For each presentation the tester recorded not only whether the identification was correct or incorrect but the listener's exact response. Confusion matrices were then constructed to illustrate not only how often a given consonant was identified correctly, but how often it was confused with each other consonant. A total of 16 different consonants was used. Results showed that, in the case of high-pass filtering, errors were randomly scattered. With either masking noise or low-pass filtering, however, the confusion matrices showed rather consistent patterns of confusion, suggesting that the 16 phonemes could be characterized by a system of five separate and distinct articulatory dimensions: voicing, nasality, duration, affrication, and place of articulation. The low-pass filtering and masking noise had little effect on voicing and nasality but severely affected place of articulation. The analysis further suggested that the perception of any one of these five dimensions is apparently independent of the other four. As Miller and Nicely put it, ". . . it is as if five separate, simple channels were involved rather than a single complex channel."

Moser and Dreher [40] evaluated the effects of both training and number of speech sounds per stimulus on the intelligibility of monosyllables. Relative to the question of training, the authors observed a pronounced improvement with practice and concluded that the effect of training can be ignored in experimental studies only at the risk of rendering other controls invalid. Relative to the number of sounds per word, results showed that, with one exception, correct identification of monosyllables declined as the number of sounds per word increased. The exception occurred for two sound monosyllables which were superior to all other lengths, even with minimal training of listeners. Because of the apparent dependence of intelligibility on the number of sounds in the monosyllable, Moser and Dreher analyzed representative PB lists to determine their homogeneity with respect to this variable. An analysis of eight PB lists showed a considerable difference in the phonetic lengths of the words, both within a list and between different lists. Moser and Dreher take note of the important implications to the audiologist inherent in these findings.

Black [41] presented nonsense syllables to listeners through a two-channel system in which a time delay could be inserted in one channel. Although intelligibility changed as a function of delay interval, Black was unable to find a delay in the interval from 0 to 0.33 second in which intelligibility was better than through a single direct presentation without delay.

Localization.—The problem of directional, or stereophonic, hearing has occupied a number of investigators for many years. A bibliography on this single topic, recently prepared by Wright,[42] contains references to more than 450 papers dating from 1856 through 1955. While attempts to isolate the factors responsible for our ability to localize a sound in space have been pursued primarily in the interest of auditory theory, research in this area has taken on new meaning, within the past few years, with the development of practicable stereophonic hearing aids (i. e., a separate microphone, amplifier, and receiver for each ear, with the microphones mounted near the ears).

The potential advantage of this development to many hearing-aid users will undoubtedly stimulate, in the immediate future, considerable research on the relative performance of the monaural versus the

binaural aid. Here, again, the audiologist may draw on a rich fund of basic material.

A typical example, in 1955, was the paper by Sandel, Teas, Feddersen, and Jeffress.[43] These investigators used an "acoustical-pointer" method to study localization of tones presented from either single or paired speakers. The pointer was a small loudspeaker which the subject could rotate through a circle around his head. The loudspeaker presented a noise signal which alternated with the tone to be localized. Results supported the conclusion that for frequencies below 1500 cps the phase or arrival time difference at the two ears is the dominant factor in determining localization ability, while for frequencies above 1500 cps the intensity difference between the two ears is the dominant factor.

König and Sussmann[44] studied the influence of involuntary head movements in localization. Using a sensitive device for detecting very slight movements, they found that involuntary motion was taking place even when both the subject and the tester believed that the head was absolutely steady. Movements were of two types. Some, occurring at irregular intervals of several seconds, varied from three to five degrees. Others were synchronous with the pulse and also reached amplitudes of five degrees. König and Sussmann found that localization became quite poor when these minor head movements were eliminated by attaching the pick-up microphones to a rigid, artificial head.

In an extremely provocative study Bocca[45] attempted to evaluate the factor of central integration in binaural hearing. Speech was delivered to the subject's two ears through two separate channels. One channel permitted variable attenuation of the speech signal, while the other provided 500-cps, low-pass filtering. The level of the speech in the unfiltered channel was first set at a point where the subject's discrimination score was no better than 30%. The filter in the other channel served to reduce the discrimination score to about 50% on that ear. When speech was presented to the subjects two ears simultaneously through the two channels, however, the discrimination score became much higher and was, in fact, approximately equal to the sum of the two monaural scores.

Masking, Duration, Thresholds—In his characteristically ingenious manner Pollack[46] took a fresh approach to the problem of masking by noise, using a masking signal that was neither continuous nor interrupted but periodically intermittent (i. e., intervals between successive noise bursts partially filled with noise). Results showed that the masked threshold for a 1000 cps tone, under a wide range of intermittency conditions, could be described in terms of the masking produced by a completely interrupted noise and the masking produced by a continuous noise at the same level as the noise in the partially filled segments between successive bursts.

Interrupted white noise was also used as a stimulus by Symmes, Chapman, and Halstead.[47] These investigators varied its repetition rate in order to determine the threshold for fusion, that is, the interruption rate at which the noise sounded continuous. In a sample of 46 normals the mean "critical fusion frequency" was 82.1 ips, with a standard deviation of 19.4 ips. The signal was presented at an SPL of 70 db, with a sound-time fraction of 0.90.

Wertheimer[48] and Oldfield[49] studied the variability of auditory thresholds over long periods of time. Wertheimer was concerned with the simultaneous variability of both the auditory and the visual absolute thresholds, while Oldfield studied fluctuations in the difference limen for sound intensity.

Wertheimer found significant shifts in auditory and visual thresholds both within a day and from day to day, but there was no significant correlation between fluctuations in the two sensory modalities.

Oldfield also noted marked and irregular fluctuations in the difference limen, with excursions as great as 100%. There was no evidence of any regular periodicity in

these fluctuations, however. Rejecting the possibility that these fluctuations reflected a property of the ear itself, Oldfield suggests a central basis for the phenomenon.

Applied Audiology

Measurement of Hearing Impairment.—Studies in this area may be divided into two categories: those concerned with the measurement of threshold acuity and those directed toward the evaluation of suprathreshold hearing.

While papers on threshold measures, during 1955, ranged from whispered voice test to the Békésy audiometer, the majority of studies reflected a growing interest in PGSR audiometry, particularly as a diagnostic aid in small children.

Maspetiol, Pigement, and Tronche[50] presented a technique for detecting the uncomfortable loudness level by noting the sensation level at which an auditory signal evokes a GSR response in the nonconditioned subject. If this sensation level is less than 50-60 db., recruitment, and hence cochlear injury, may be presumed. Maspetiol et al. consider this approach to be useful in children, especially in differentiating between the reversible cochlear and the nonreversible neural components of meningitis. They also noted that, in Rh-incompatible children and in cases of skull injury, there might be a discrepancy between the results of PGSR and conventional audiometry. The discrepancy was attributed to "deafness of central origin."

Lesák[51] also noted a difference between PGSR and conventional audiometry in children (20 db.), but he interpreted the difference in terms of incomplete development of the child's psychic and communicative faculties which penalized him on the conventional test.

Two Italian investigators, Benciolini and Fraccaroli,[52] described a variation of the PGSR approach in which the subject is conditioned to respond when a light signal goes on. By coupling the light flash with an acoustic signal the subject can be conditioned to respond when only the acoustic signal is given. The authors emphasize the value of this approach not only for unmasking malingerers but as a means of approximating the audibility threshold.

Two studies of PGSR are especially noteworthy because of their direct experimental approach to an evaluation of the many variables involved in this often oversimplified problem.

Goldstein, Polito-Castro, and Daniels[53] attempted to determine the relative ease with which PGSR responses to pure tone could be elicited in 32 normally hearing children of average to superior I. Q. According to defined subjective stndards 18 children were judged "easy" to condition, while 14 were judged "difficult." Ease of conditioning was found to be unrelated to the following factors:

1. I. Q., as measured by performance test
2. Sex
3. Age (range from 7½ to 12 2/3 years)
4. Handedness
5. Initial, terminal, or maximum resistance
6. Random fluctuations of resistance
7. Latency of response
8. Overt responses and behavior (except sleepiness)

A possible relation between ease of conditioning and minimum resistance was noted. A previous study by Goldstein, Ludwig, and Naunton had shown that deaf children were relatively easy to condition. In attempting to explain why the normal children in the present study were more difficult to condition, Goldstein et al. hypothesized that, because of the normal child's exposure to a constant background of sound, meaningless stimuli like pure tones will soon fail to elicit responses from him.

The second noteworthy study of PGSR was described in the thorough monograph by Barr.[54] This investigator set out to determine the extent to which two different types of audiometry, "play" and PGSR, were actually applicable in preschool children of various ages. After evaluating tests on 324 children under the age of 7, Barr reached the basic conclusion that play audiometry could be successfully used only

rarely with children under 2½ years, while PGSR was possible in many cases (although it failed on an equal number) for children in the range from 1 to 2½ years. Barr emphasized, however, that both play and PGSR audiometry require a certain developmental level, and that the choice between the two methods should be based on the further considerations that play audiometry equipment is less difficult to operate, the method is less time-consuming, requires less personnel, and is based on a pleasant rather than an unpleasant experience for the child. Thus, concludes Barr, assuming that the child is old enough, play audiometry should always be tried first, and PGSR might well be reserved solely for cases in which play audiometry has failed or where, because of the child's age, it might be expected to fail.

Although the majority of investigators are concerned with its use in children, PGSR is not necessarily restricted to the younger age group. At the other extreme, Bordley and Haskins[55] studied PGSR responses in a group of elderly subjects who failed to profit from hearing-aid use in spite of favorable audiometric contours. It was found that, in these subjects, PGSR thresholds were better than conventionally obtained thresholds. Relating this observation to studies of decerebrate animals, the authors suggest that the difference between the PGSR and the standard threshold indicates the approximate degree of cerebral sclerosis in the auditory area of the brain. In this connection it is interesting to observe the similar result, noted above, obtained by Maspetiol et al. in the Rh-incompatible and skull-injury cases.

In the literature on conventional audiometry, problems of measuring hearing by bone conduction continue to occupy a prominent position. Lüscher and König,[56] in discussing the sensitive question of how to mask out the opposite ear during bone-conduction testing, remind us that the masking sound must eliminate the possibility of hearing the test tone on the contralateral ear while, at the same time, exerting no influence whatever on the test ear. This is best accomplished, according to Lüscher and König, by using an air-conducted pure-tone stimulus as the masking sound.

Goodhill and Holcomb[57] emphasize the importance of controlling the pressure with which the bone receiver is applied to the head. They recommend that the headband of the bone receiver should be made adjustable so that a constant pressure of no less than 400 gm. may be applied in all cases. They point out, however, that, in spite of this precaution, variation in the compliance of the skin may cause errors of 5 db. or more in some cases.

Both Goetzinger and Proud[58] and Coen[59] measured speech thresholds by bone conduction and reported a high correlation with pure-tone thresholds. They recommend the procedure as a check on the reliability of pure-tone bone results.

Finally, Suzuki and Ichihawa[60] found that, in those cases where satisfactory masking of the nontest ear could not be achieved, good results were obtained by using a beating tone on the test ear.

In conventional air-conduction audiometry, studies have been pursued on several fronts. Goodhill[61] emphasized the importance of pure-tone audiometry in following the moment-to-moment progress during stapes mobilization and described a method for doing this with a commercial audiometer.

Fisch[62] analyzed the audiograms of 250 cases of congenital deafness and found that they could be divided into three main types: "flat," "sloping," and "residual." Further analysis suggested that the "flat" loss was due to developmental arrest in the organ of Corti, while the sloping audiogram, with greater loss for high frequencies, resulted from pathological conditions either at birth or in the early postnatal period. "Residual" audiograms were primarily associated with cases of hereditary loss, but the occurrence of other audiometric types in the hereditary group suggested the possibility of more than one distinct pathology in the various losses

now classified under the single term "hereditary."

In view of the rapidly expanding field of automatic audiometry it is unfortunate to find so little research being carried out on the effects of the many variables involved in these procedures. A notable exception, in 1955, was the comprehensive paper by Corso[63] concerning the Békésy-type audiometer. In 90 subjects Corso evaluated the effects of three testing times (5, 10, and 20 minutes), three attenuation rates (0.5, 1, and 2 db. per second), and test-retest reliability. Results indicated that, although neither testing time nor attenuation rate had any effect on the mean threshold (at 1000 cps), attenuation rate affected both threshold variability and test-retest reliability. The slowest attenuation rate (0.5 db. per second) gave optimal results.

In a study of the classical spoken and whispered voice tests Flottorp[64] confirmed what many had long suspected, namely, that (1) the acoustic properties of ordinary rooms vary with respect to ambient noise and reverberation, (2) the inverse-square law does not hold too well in enclosed rooms, and (3) the difference in vocal intensity from one examiner to another is often substantial. Of particular interest was the observation that all examiners tended to increase vocal intensity when the distance to an imaginary patient was increased. Flottorp feels that, while the spoken voice tests may yield some gross information about a patient's hearing acuity, they are not suitable for an "objective gradation" of hearing.

No area of audiology, during 1955, prompted more papers than the single topic of suprathreshold tests. Contributions to the problem of evaluating hearing above the impaired threshold continue to pour in from literally every corner of the globe. This extraordinary degree of interest undoubtedly stems from two felt needs: first, the problem of evaluating the social adequacy of a patient's residual hearing, and, second, the problem of differentiating, primarily for diagnostic purposes, among the various subcategories of sensorineural (perceptive) loss.

One of the most important methods for evaluating suprathreshold hearing is to test the subject's ability to understand speech. In the past the traditional approach to this problem has been the so-called PB, or phonetically balanced, list of monosyllables. Silverman and Hirsh[65] point out, however, that although a particular type of speech material may prove useful for one clinical purpose (e. g., diagnosis) it may not necessarily be of comparable value for another clinical purpose (e. g., assessing social adequacy). They note, for example, that in measuring discrimination loss for diagnostic purposes speech is useful not because it is a particular type of sound, but because it is a particular type of auditory signal (with, as yet, only poorly defined properties). On the other hand, in the assessment of social adequacy the validity of speech material is intimately related to the fact that it is a particular type of sound (i. e., the type of sound used in most human communication). In view of these considerations Silverman and Hirsh stress the need to think in terms of different test materials for different purposes.

In connection with one phase of the diagnostic use of speech tests Walsh and Goodman[66] presented a detailed account of four cases with retrolabyrinthine lesions in which poor speech discrimination was observed, often in the absence of recruitment. These observations led the authors to conclude that, contrary to the previous findings of Dix, Hallpike, and Hood, discrimination loss does not differentiate between cochlear and retrocochlear lesions. They advise, therefore, extreme caution in interpreting poor discrimination as evidence against a retrocochlear lesion.

Schubert[67] described a technique in which the speech test material was recorded with a five-second reverberation time. The increased difficulty of this new test appeared to be of some value in detecting relatively minor problems that would have been missed

in the more gross conventional approach. The potential value of the technique in the investigation of central hearing problems caused by head trauma is also noted.

Bocca et al.[68] used a slightly different approach to the problem of increasing the difficulty of the discrimination test. They sent the speech material through a low-pass filter with a cut-off frequency of 1000 cps and used the resultant signal to measure discrimination loss in cases with temporal lobe tumors. Results indicated consistently poorer discrimination in the ear contralateral to the cortical lesion, in spite of the fact that both pure-tone and speech thresholds were normal for both ears. In 20 to 30 days after operation to remove the tumor, the discrimination loss had disappeared. According to the authors, this technique represents the only satisfactory means of showing hearing disorders in the upper auditory pathways.

Palva[69] continued his investigation of the masking effects of white noise in 67 hearing-loss subjects of various types. In this study the masking noise was not continuous but interrupted at a rapid rate. Results suggested that neither the masking for pure tones, nor the masking for speech, nor the discrimination score in noise at a signal-to-noise ratio of 10 db. were useful in differentiating the various clinical groups of hearing loss (e. g., conductive from perceptive, recruitment from nonrecruitment, etc.).

One of the most interesting and provocative uses to which speech material has been put in clinical audiology is undoubtedly the delayed speech feedback test in which the subject's own speech is fed back to his ears after a slight time delay. Although the phenomenon has aroused considerable interest in many fields, audiologists have tended to view it primarily as a technique for the detection of malingerers. Ewertsen,[70] for example, emphasizes its importance as one of a battery of different malingering-detecting procedures at the disposal of the clinician. Feeling that it is both reliable and reproducible, he takes particular note of the fact that it is readily intelligible to both laymen and lawyers; hence it has considerable potential value in the medico-legal sense.

In studying the persistence of the delayed feedback effect after the delay had been removed, Black[71] found that reading rate continued to be affected for at least 150 seconds.

Recruitment and Allied Phenomena—The measurement of recruitment continued to receive considerable attention in the clinical literature during 1955.

Hedgecock[72] reemphasized the diagnostic value of the phenomenon and described several techniques which he believes are suitable for the clinical measurement of recruitment.

In an even more optimistic vein, Harbert and Sataloff[73] state that, since recruitment can be established by tests simple enough to perform in an otologist's office, it should be routinely examined in all patients with sensorineural loss. They emphasize, in particular, its value in localizing the predominant site of pathology in patients whose clinical picture is otherwise obscure.

Further substantiation for the value of recruitment in establishing the site of lesion was afforded by Yantis.[74] This investigator reviewed a major share of the published evidence on recruitment and classified all of the loss cases in these studies into five groups according to the locus of the responsible lesion. After analyzing the experimental results within each group, Yantis felt that there was overwhelming evidence to support the conclusion that recruitment occurs only in lesions affecting the senory end-organ and is not to be expected in lesions affecting either the eighth nerve or higher auditory pathways.

One method that has been advocated for the clinical detection of recruitment is the measurement of the intensity difference limen. Considerable confusion existed in this area in 1955, however, as a result of a series of apparently conflicting findings.

In an attempt to shed further light on this problem, Jerger [75] measured differential intensity sensitivity by the quantal psychophysical method in normals and in subjects with hearing loss accompanied by recruitment. Two principal findings are of interest here. First, the intensity difference limen was significantly smaller in the case of hearing loss with recruitment than in the case of normal hearing at sensation levels of both 10 and 40 db. Second, the difference between normal and pathological ears was manifest principally as a marked increase in the slope of the psychometric function for differential intensity sensitivity. It was noted, however, that, in agreement with the position of Hirsh, Palva, and Goodman and, more recently, Langebeck,[76] the experimental results could not be satisfactorily explained in terms of an increased slope of the loudness function. Rather it was suggested that the apparent abnormal sensitivity to intensity change results from fundamental changes in the ear's response to sustained stimulation as a result of end-organ lesion.

Lüscher,[77] whose 1948 paper initiated the current interest in difference-limen testing, described his new version of the original Lüscher-Zwislocki test and reemphasized its topical-diagnostic significance.

Tomdorf, Brogan, and Washburn [78] investigated the intensity difference limen in normal ears by the amplitude modulation method as a function of several stimulus parameters: ascending versus descending mode of testing, frequency and intensity of the carrier wave, and pattern and frequency of modulation. Results were interpreted to indicate that loudness is not a direct but a complex function of the difference limen.

Another method that has sometimes been advocated for the indirect measurement of recruitment is the difference limen for frequency. It has been suggested that, in end-organ lesion, the pitch DL is abnormally large. Fournier [79] has routinely determined the pitch DL, by a frequency modulation technique, in all of his audiometric testing for the past three years. Analysis of these data led him to conclude that an abnormally large pitch DL is associated with disturbance of pitch perception, impaired speech intelligibility, and generally poor prognosis for hearing-aid use.

One of the more recently proposed methods for detecting recruitment is the measurement of aural harmonics. Opheim and Flottorp [80] used the conventional "best-beats" technique to measure aural harmonic thresholds at 250 and 500 cps in a large number of patients with various types of hearing loss. Results showed that in conductive loses the aural harmonic threshold was generally higher than normal, in sensorineural losses without recruitment it was normal, and in sensorineural losses with recruitment it was well below normal. On the basis of these results the authors recommend the procedure as a diagnostic test for demonstration of the recruitment phenomenon.

Still another recruitment test, originally proposed by Metz, is based on the detection of the reflex contraction of the intra-aural muscles by noting a change in the ear's acoustic impedance. Thomsen [81] presents a detailed description of the Metz test and evaluates its potential. Since the reflex normally occurs only if the ear is stimulated by a tone 70-90 db. above threshold, elicitation of the reflex by a tone at a sensation level of less than 70 db. is presumed to indicate the presence of recruitment in the ear under test. The principal advantage of the Metz method, according to Thomsen, is its objectivity. No subjective response is required from the patient. His role is entirely passive. The method's main disadvantage, however, is that changes in the contralateral middle ear may prevent the reflex from occurring, leading to a false negative test result.

In a second paper Thomsen [82] noted the clinical application of the Metz test for purposes other than recruitment, and, in still a third paper,[83] he described a case of psychogenic hearing loss in which the pa-

tient denied hearing anything in one ear. Neither pure-tone audiometry, speech audiometry, nor delayed speech feedback was able to demonstrate any hearing on this ear. Bilateral intra-aural muscle reflexes were easily evoked, however, by measuring the impedance change in the contralateral ear.

In spite of the current wave of enthusiasm for recruitment tests as diagnostic aids in differentiating end-organ from eighth-nerve lesions, exceptions to the rule continue to be noted with disquieting frequency. Jatho,[84] for example, analyzed audiometric findings in seven cases of eighth-nerve tumors. Recruitment was found in one-third of the group, a result which he ascribes to venous congestion. The qualification that interference with the cochlear blood supply could create an end-organ lesion, and hence recruitment, in a primarily retrolabyrinthine pathology was, of course, noted by Dix, Hallpike, and Hood, themselves, as early as 1948.

Closely related to recruitment, and, indeed, in Hood's view an integral part of it, is the phenomenon of abnormal adaptation. When Hood first described the phenomenon he used the term "perstimulatory fatigue" to refer to the apparent decline in an ear's response to a sustained tone. Shortly thereafter, however, he abandoned this rather cumbersome term in favor of the single word "adaptation." Quite aside from this problem in terminology, the phenomenon is quite clear. In certain cases of hearing loss the impaired ear is unable to maintain its initial response under sustained stimulation to the same extent that a normal ear would at an equivalent sensation level. In a recent paper Hood[85] attempted an explanation of his observed results in terms of a disturbance in the rate at which expended energy can be restored during stimulation. He then described some techniques said to be effective for the clinical evaluation of abnormal adaptation, noting their value in differentiating between conductive and end-organ pathology.

Palva[86] used a variation of Hood's original methodology to measure adaptation by the median-plane-localization method in normals and in subjects with various types of hearing loss. Conductive and nonrecruiting sensorineural losses were said to yield normal adaptation values, while adaptation was abnormal in only 14% of sensorineural losses with recruitment. These results would appear to contradict Hood's notion of a rather close relationship between recruitment and abnormal adaptation. Since all of Palva's comparisons were apparently done for a fixed SPL, however, it is not clear exactly what he might have concluded if he had analyzed his data in terms of expected results at equivalent sensation levels. In addition, Palva's results on normal ears showed considerably less adaptation than Hood's original data.

Despite the generally close correspondence between pure-tone thresholds in the mid-frequency region and the threshold for speech, one sometimes encounters exceptions in which the speech threshold is poorer than the pure-tone thresholds would predict. Harris, Haines, and Meyers[87] sought to determine the extent to which these "speech-tone threshold discrepancies" could be accounted for by two variables: recruitment and deterioration in pitch discrimination. Results were generally quite negative. Neither phenomenon, by itself, could account for speech-tone discrepancies when they occurred. The authors conclude that it is probably fruitless to pursue the study of isolated capacities, like pitch discrimination, as diagnostic signs. Rather, it is suggested that future research should attack the problem of the possible relationships among the variables of pitch, loudness, speech-tone discrepancy, and type of hearing loss.

In an exhaustive clinical study of presbycusis, Pestalozza and Shore[88] studied relationships among several different tests of auditory function, with particular emphasis on speech discrimination. Results clearly substantiated Gaeth's hypothesis of

a "phonenic regression" syndrome in the elderly, i. e., extremely poor discrimination in spite of relatively mild and flat hearing loss. A partial list of the authors' findings includes the fact that discrimination loss increased with hearing loss but not with slope of audiogram and that some recruitment was present in about one-half of those cases on whom a test could be performed. The paper contains a wealth of further detail on relationships among speech threshold, speech discrimination, medical history, etc., and should be consulted, in the original, by anyone who works with the elderly patient.

It is a time-honored axiom that people with perceptive losses talk too loudly because they cannot hear their own voices normally, while people with conductive losses do not talk loudly enough because they hear their own voices too well. In an attempt to quantify these impressions, Penn[89] studied the voice and speech patterns of 100 conductive and 100 perceptive losses and found that deviations in speech were, indeed, closely related to the type of loss. The following are some of the aberrations noted in perceptive losses:

1. Excessive volume
2. Nasal quality
3. Monotonous pitch
4. Rapid rate
5. Audible breathing
6. Omission of high-frequency consonants in consonantal clusters
7. Unconscious phonation

In the conductive group, by way of contrast, volume was weak and quality was more denasal.

Hearing Aids.—In view of the highly important role played by the hearing aid in clinical audiology, one is surprised to find comparatively little attention given to this important area in the literature.

Harford and Markle[90] reported some pertinent observations on a problem of widespread interest, the effect of hearing-aid use on the user's residual hearing. They described the case of a child with a severe bilateral hearing loss whose threshold curve appeared to drop 15-20 db. after three and one-half years of hearing-aid use. When the aid was shifted to the opposite ear, the threshold gradually recovered on the unaided ear but declined on the aided ear. Shifting the aid back to the first ear caused it to drop again, while removing the aid entirely brought both ears back to the preaid level. The authors feel that, in view of cases like this, there is a real need for carefully controlled studies of the effect of amplification on residual hearing.

The role of the otologist in hearing-aid selection and use was outlined by Guilford and Haug.[91] The authors feel that, in order to minimize the exploitation of the hearing-aid user by commercial interests, the otologist must be prepared to give suitable recommendations to the potential hearing-aid user and must assume greater responsibility for following up these recommendations and providing educational guidance.

Relative to the design of the hearing aid itself, Victoreen[92] emphasized the importance of good transient response in the aid, while Winckel[93] advocated a frequency response increasing gradually to 1500 cps, dipping slightly to 2000 cps, for optimum speech intelligibility.

Community and Industrial Hearing Conservation.—One of the most important steps in any hearing conservation program is the hearing survey to define and to identify the case load. Bentzen and Jelnes[94] reported a relatively high incidence of impaired hearing in Denmark. Using as their criterion of hearing loss the inability to follow speech in group conversation, they obtained a figure of 6% in a random sample of 5000 Danes, which compares with 4% for Great Britain and 1.25% for the United States. The largest group of any single etiological category was presbycusis, which comprised more than one-third of the total hearing loss group.

Mosher and Maines[95] screened 5152 preschool children in the age range from 2-7 years and found losses of 20 db. or more at two or more speech frequencies in slightly over 1% of the total group.

Fisch [96] surveyed the hearing of 89 cerebral-palsied children and found a significant degree of hearing loss in 20%. On the basis of these results the need for detailed audiometry on all cerebral-palsied children was stressed.

Webster and Solomon [97] used the NEL warble tone test to survey the hearing acuity of naval personnel assigned to submarines. Of the 1053 men tested, 10% showed a hearing loss of 18 db. or more at high frequencies (4000 and 7000 cps).

Interest in the problem of conserving the hearing of workers exposed to high levels of noise, both in military and industrial situations, continued its rapid growth during 1955. The literature now abounds with suggested preventative measures, including preemployment and follow-up audiometry, reduction of noise at the source, use of ear-protective devices, exclusion of personnel with existing hearing loss from noisy jobs, and controlling the length of time a worker spends in the high-level noise environment. One or more of these measures were described by Conant,[98] Fabian,[99] Kostelijk,[100] Sataloff,[101] Hribar,[102] Bostic and Worsham,[103] Ireland and Hodges,[104] and Pierangeli and Ghirlanda.[105]

Suggested methods for the practical implementation of hearing conservation programs were offered by Glorig,[106] Wheeler,[107] and Hanks.[108] Glorig described a card for recording audiometric data utilizing an IBM coding system, while Wheeler discussed, in basic terms, the audiometer, the audiogram, the concept of normal hearing, physical requirements for satisfactory audiometry, screening techniques, etc., in terms of their application to industrial audiometric programs. In a similar manner Hanks outlined, in lucid fashion, how the industrial physician can initiate and carry forward a hearing conservation program.

Cox [109] described a method for determining the maximum allowable SPL per octave band in ambient room noise in order to be sure that the noise will not interfere with an audiometric testing program, and Williams [110] presented a basic discussion of sound-measuring instruments.

Finally, medicolegal aspects of the industrial noise problem were discussed by McLaurin [111] and Glatzel.[112]

In pursuing the study of individual differences in noise susceptibility, Nesswetha [113] found that the percentage of susceptible ears was independent of age and that acoustic "weakness" appeared to be related to visual "weakness." These findings suggested the hypothesis that susceptibility to noise-induced hearing loss is a constitutionally determined factor.

The possible utilization of apparent differences in noise susceptibility as a means of predicting, and thereby preventing, noise-induced hearing loss is a problem that has recently interested a number of agencies, both for its theoretical and applied aspects.

The primary problem here is, of course, the difficult and time-consuming task of validation, i. e., the problem of demonstrating that the proposed predictive test actually does predict subsequent noise-induced hearing loss. Working under contract to the USAF School of Aviation Medicine, Carhart and Jerger [114] developed a method for the rapid measurement of temporary threshold shift after brief acoustic stimulation. The methodology was designed for use in the type of large-scale field study essential to the validation of the basic premises underlying the use of the temporary threshold shift as a predictor of noise-induced hearing loss.

In summary, the series of papers cited above serves to illustrate the breadth and scope of what is perhaps the most rapidly expanding branch of applied audiology, community and industrial hearing conservation. The appearance of the new journal *Noise Control* is further testimony to the degree of current interest in these problems. One may anticipate even wider interest and activity in this area in the years to come.

New Books and Journals

In addition to regular journal publications, 1955 saw the introduction of two new

sources of audiological literature. In January of 1955, the American Institute of Physics published the first issue of an entirely new journal, *Noise Control*, devoted to filling the needs of workers in various areas—engineers, management, architects, audiologists—in short, everyone for whom the control and reduction of noise presents practical problems.

Nineteen fifty-five also saw the introduction of the *Translations* series, published by the Beltone Institute for Hearing Research and under the editorship of Charles Lightfoot. This series publishes English translations of foreign-language articles concerned with problems relating to hearing for the benefit of persons who are not rapid readers of all the languages in which audiological research appears.

Two excellent bibliographies were published in 1955. The new "Bibliography on Hearing," by Stevens, Loring, and Cohen,[115] constituted an enlargement of the original two-volume "Bibliography in Audition." Many new references were added, and the entire coverage was brought up to date through 1952.

Of special value to workers in the area of hearing conservation was the annotated bibliography "Noise, Its Measurement, Effects and Control,"[116] published by the Industrial Hygiene Foundation of America. The bibliography contains selected references relating to the measurement of sound and noise, the effects of noise, the measurement of hearing loss, and the reduction and control of noise.

Two books of particular interest to the otologist appeared in 1955. "Functional Otology,"[117] by Heller, attempts to show how the techniques of audiological testing and acoustic rehabilitation can be integrated with otologic practice.

A large number of topics (pure-tone and speech audiometry, recruitment, hearing aids, nonorganic deafness, voice and speech production, auditory rehabilitation, to name only some) are covered. The book presents a comprehensive overview that should be of value to many otologists.

Finally, 1955 saw the publication of the monumental five-volume series "Otolaryngology."[118] These five volumes, edited by Coates, Schenck, and Miller, contain a series of papers by eminent authorities encompassing virtually every facet of otolaryngology from anatomy, physiology, and pathology to the psychology of deafness. Volumes I and II are of particular interest to the audiologist.

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Audiology Section

JOSEPH SATALOFF, ASSOCIATE EDITOR

Masking Levels for Clinical Use

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The main clinical purpose of masking is to eliminate one ear while testing the other by either air or bone conduction. To accomplish this one may use a stream of air, water, or sound to "occupy" one ear while testing the other. In most practical situations, sound is the most flexible, measurable, and subjectively acceptable medium. Most commercial audiometers are equipped with either random (white) noise or saw-tooth noise generators, and the masking sound is delivered by one of the earphones. While this is perhaps neither the best type of sound nor best method of delivery, we should know the effectiveness and limitations of the present method. There is as yet no rigidly established and generally accepted criterion of masking intensity. It is well known that when a narrow band of noise covering both sides of the frequency tested is used instead of a wide-band type a much lower level of masking is effective. Similarly, if masking is applied to a smaller area, e. g., via a perforated earplug instead of through a headphone, there is less cross masking at high intensities. Either or both of these methods may be required to adequately mask an ear with a well-marked conductive deafness.

The purpose of this study was to determine the effectiveness of 80 db. of white noise re normal threshold (100 db. re 0.0002 dyne per square centimeter) as a mask for eliminating hearing in the contralateral ear during bone-conduction testing. The degree of overmasking produced by such an intensity was also investigated. This intensity was selected because it is the maximum that most patients with normal hearing will tolerate without distinct discomfort.

The ability of sound of this intensity to mask air conduction is well established, as indicated by total absence of air conduction within the limits of the audiometer in the vast majority of unilateral-deafness cases. When there is a response at one or more frequencies it is usually near the upper limit of the audiometer and well below the levels of measurable bone conduction. Frequencies below 256 were not tested.

Much of the confusion and differences of opinion in regard to the intensities required for masking is due to the dual scale used in instrumentation and clinical work and the absence of reliable data with respect to crossed hearing during masking.

Figure 1 shows the spectra of two commercial random noise sounds compared with that of the interphone trainer unit source used in these experiments. At the time these studies were started, the better white-noise commercial sources shown were not available. Since this study was initiated, many tests were made with both Peters and Audivox white noise at the same over-all intensity, with very similar results. Differences in the spectrum of noise with different machines are minimized by using high-in-

Accepted for publication Nov. 15, 1956.

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Data for this study were compiled by the personnel of the Speech and Hearing Clinic of the U. S. Naval Hospital, Philadelphia, and statistically analyzed by Dr. H. Menduke, of Jefferson Medical Center. Electronics data were supplied by Mr. Raymond Lazinski.

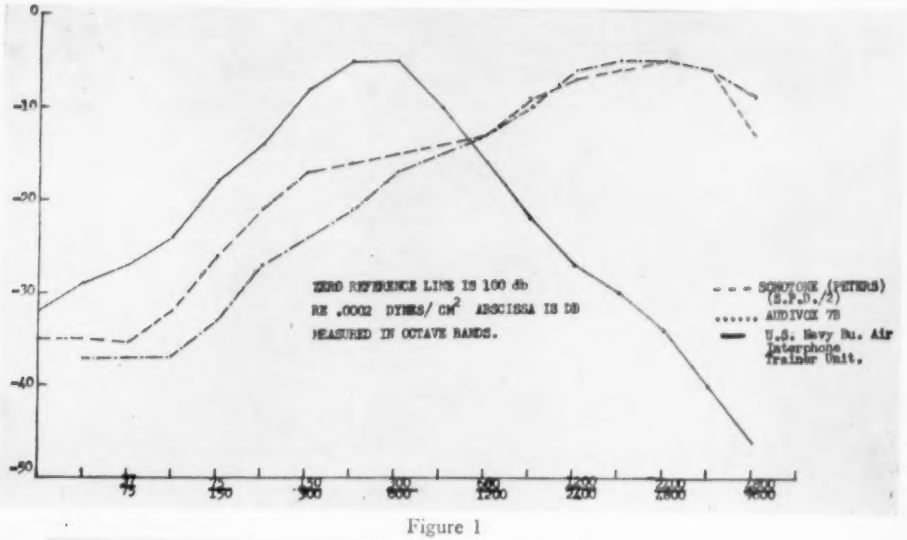
ZERO REFERENCE LINE IS 100 db
RE .0002 DYNES/ CM^2 ABSCISSA IS DB
MEASURED IN OCTAVE BANDS.
SONOTONE (PETERS) (S.P.D./2)
AUDIVOX 7B
U.S. Navy Bu. Air Interphone Trainer Unit.

Figure 1

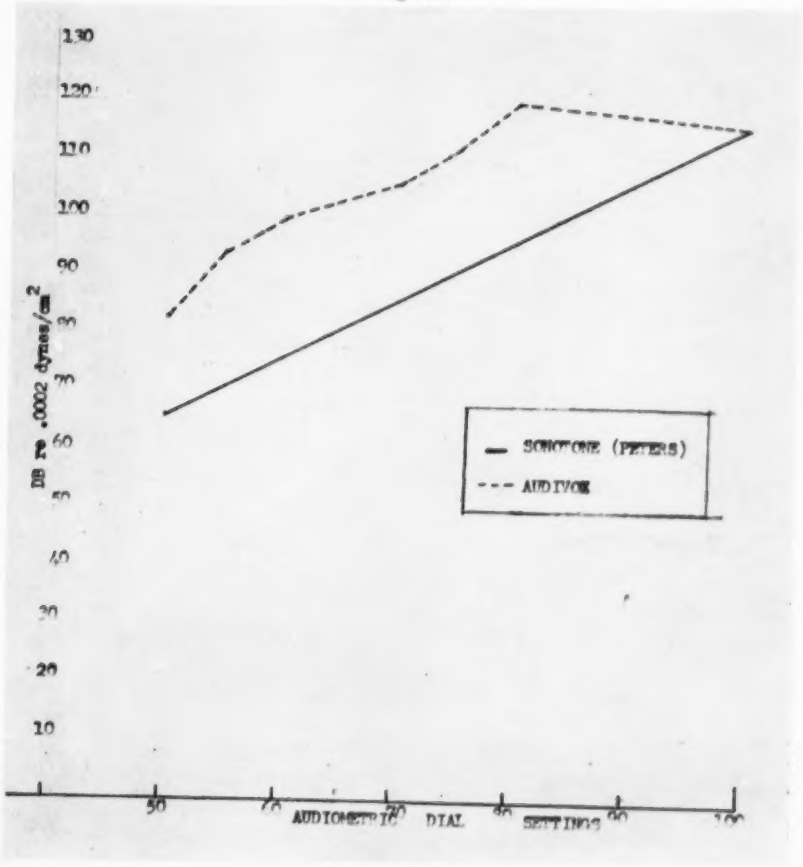

Figure 2

tensity masking because masking extends over a wider area as intensity is increased.

In the Sonotone (Peters) S.P.D.-2 audiometer, the white-noise reference of 80 db. corresponds roughly to the intensity of the 1000-cps tone with a dial setting of 80. In other words, 80 db. of white noise has the same subjective intensity as 80 db. of a 1000-cycle pure tone or the reference level is average threshold of audibility. This level for 1000 cycles is about 15 db. above 0.0002 dyne per square centimeter. The dial settings of the Audivox and most American audiometers are based on "effective" masking; i. e., the settings indicate the level of a pure tone which should be masked out at this level if presented to the same ear. Figure 2 shows a comparison of the scales of a Sonotone (Peters) S.P.D.-2 and Audivox 7B with reference to 0.0002 dyne per square centimeter.

In this study records were made of bone conduction with the oscillator placed over the mastoid in the usual manner and repeated with the opposite ear masked at 80 db. noise re normal threshold. In addition, a number of cases were studied at levels below and above 80 db. (100 db. re 0.0002 dyne per square centimeter). The audiometer was a Western Electric 6B, and the mask was the interphone trainer calibrated on the basis of average threshold. Unless otherwise specified, the decibel reference level in these discussions will be re average threshold (add 20 db. to convert to 0.0002 dyne per square centimeter).

Normal Subjects

In 11 subjects with normal hearing, bone conduction was tested in the usual manner with both ears open (zero reference line of Fig. 3). Tests were then repeated with receiver occlusion of the opposite ear without sound, and then with 80 db. of noise.

The use of one receiver produced a significant reduction in hearing loss at the lower frequencies but had no significant effect at 1024 cps and higher. The use of two receivers had much the same effect as the use of one, except that there was a slightly greater reduction of hearing loss from 256 to 1024 cps, inclusive, no significant effect at 2048 cps, and a significant increase in hearing loss at 4096 cps. This increase in hearing loss for frequency 4000 when both ears are covered suggests that the "normal" level of bone conduction for this frequency is based on air conduction rather than bone conduction. This should be kept in mind to avoid an erroneous diagnosis of incipient high-tone deafness in a purely conductive lesion. When the opposite ear was masked at 80 db., there was a significant increase in hearing loss at the three lower frequencies and no significant effect at the two higher frequencies (see Fig. 3). This effect on the lower frequencies was of the order of 5 db. Bone-conduction readings in this normal group varied from -15 to $+15$ for individual frequencies, but the great majority were in the 0 to $\pm$ 5 db. range. If effective binaural mask at 1024 cps is taken as a base line, the mean effective masks at the other frequencies were $+4.5$ db. at 256 cps, $+1.0$ db. at 512 cps, -6.5 db. at 2048 cps, and -1.5 db. at 4096 cps. These differences were not statistically significant.

It is also of interest to consider how much absolute binaural masking is necessary to eliminate all or most ears at all frequencies, diregarding no-mask, no-receiver loss. For the 11 normal subjects, no ear was eliminated at any frequency by either 60 or 70 db. and very few by 80 db. A binaural mask of 90 db. was sufficient to eliminate all ears at 1024 and 2048 and all but one at 512 cps. Six out of ten were eliminated at 4096 and only two at 256 cps. At 100 db. all were out except three at 256 cps.

Five cases with bilateral symmetrical nerve deafness were subjected to binaural masking as were the normals. Of these, all retained hearing in some frequency at 80 db. binaural masking, nearly all frequencies were out at 90 db., and only one case showed hearing at 256 at 100 db. While this num-

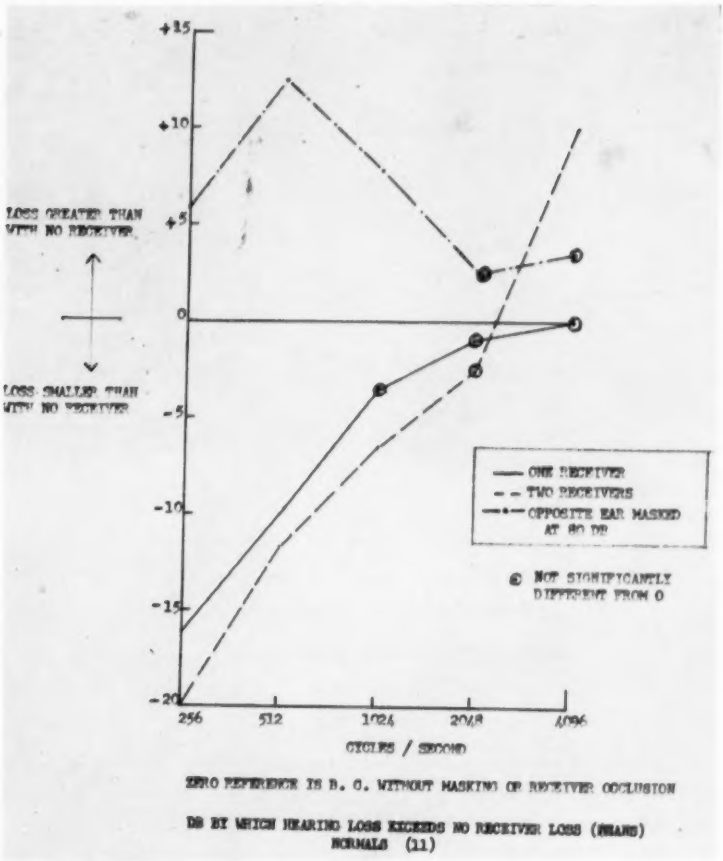

Figure 3

ber is too small from which to generalize, it appears that perceptive-deafness cases respond to masking very similarly to subjects with normal ears.

Unilateral-Deafness Cases (Seventeen)

Cases of unilateral deafness were selected on the basis that the air-conduction shadow curve either completely or nearly completely disappeared within the limits of the audiometer when the good ear was masked at 80 db. re normal threshold.

Of these, nine cases had no loss greater than 10 db. at any frequency by air conduction and eight cases had a loss of 15 db. or more in one or more frequencies in the good ear. In the analysis no significant differences were noted in the results, and they are therefore considered as one group.

For the 17 cases in this combined group, observations were made on all bad ears without mask or receiver and without mask but with receiver on the opposite ear; corresponding observations were made on the good ears of only 11 of these.

There was no appreciable effect of a blank receiver on the bad ear while testing the good ear at any frequency. There was, however, a highly significant reduction in hearing loss of the bad ear (at 256, 512, and 1024 cps) when the good ear had a blank receiver. No effect was observed at the two higher frequencies (see Fig. 4). As may be seen from a comparison of Figures

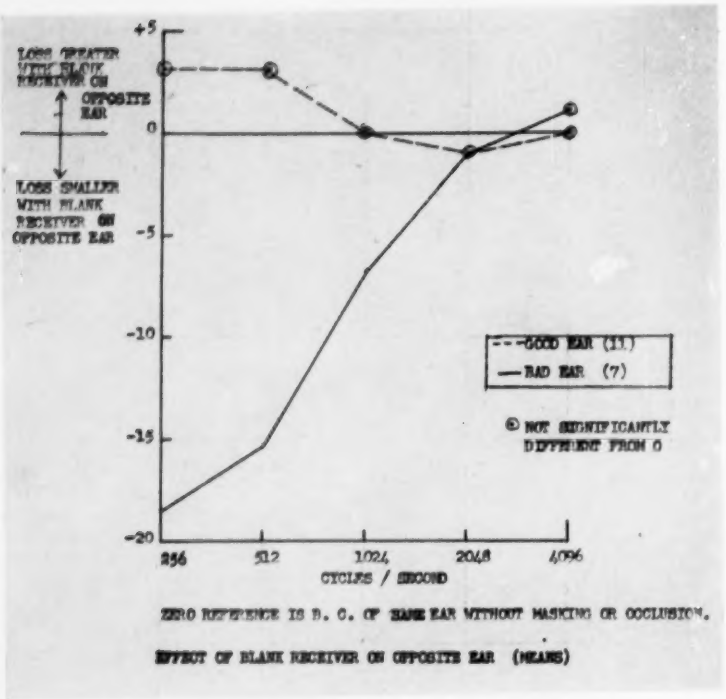

Figure 4

3 and 5, the apparent response of the bad ear to a dead receiver on the good ear is quite similar to that of the ear of a normal person when one receiver is used. Without mask or receiver, the bad ear showed rather consistently a slightly greater loss than the good ear. With a blank receiver on the good ear, however, the bad ear showed a significantly smaller loss than the good ear at the lower frequencies (see Fig. 5).

When the bad ear was masked at 80 db., there was a rather small, but statistically significant, mean increase in hearing loss at 256 and at 512 cps. This was of the order of 5 db. (see Fig. 6). When these changes are compared with the corresponding ones for normal subjects, the pattern is very much the same and represents the degree of overmasking.

When the good ear, however, was masked at 80 db., there was a very marked increase in the hearing loss measured at the bad ear. Since all hearing at the bad ear is crossed hearing from the good ear, the change in hearing measures the effectiveness of the mask.

Lest the conclusion be drawn from Figure 6 that masking is less effective for frequency 4096 than for the speech frequencies, attention is directed to Figure 7, which shows that for this frequency masking is very efficient. The apparent discrepancy is believed due to the fact that a number of cases had considerable loss in this frequency, and the differences between the limits of the audiometer and the initial loss are therefore small. Maximum losses measurable on this machine (Western Electric 6B) are as follows:

256	36 db.
512	45 db.
1024	55 db.
2048	60 db.
4096	65 db.

At 70 db. only about one-third of the ears were eliminated at each frequency.

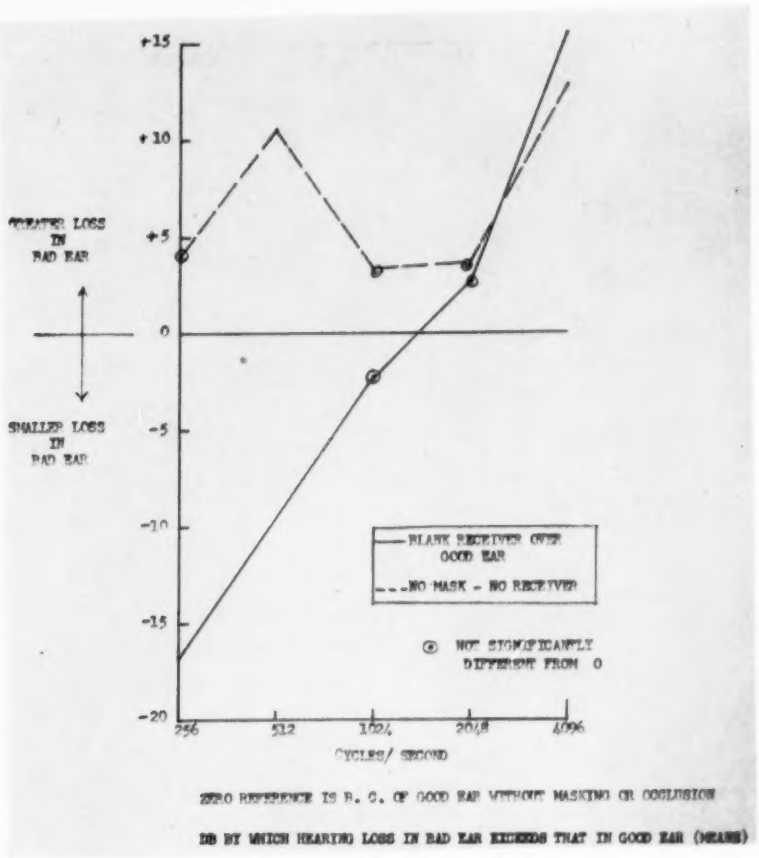

Figure 5

At 80 db. there was still some hearing in 10 ears at 256 cps. In eight of these, however, the loss was within 5 db. of the capacity of the machine. Only one ear remained at 512 cps, also within 5 db. of the capacity of the machine. At 1024 cps three ears remained, one with a loss of only 5 db. less than the capacity of the machine and two with a loss of 15 db. below capacity. At 2048 cps five ears remained, one of which was 5 db. below, one 10 db. below, one 20 db. below, and two were 25 db. below machine capacity. At 90 db. two ears were left at 256 and at 4096 cps and one at 512, 1024, and 2048 cps. One hundred decibels was sufficient to knock out all except one at 512 and one at 1024 cps.

Overmasking

In comparing the no-mask, no-receiver loss of the good ear with the loss when the opposite (deaf) ear is masked at 80 db., the difference should represent purely physical overmasking, since presumably the dead ear does not hear the masking sound. Eighteen such cases were tabulated, with the following conclusion: At the 1% level there was a significant overmasking at 256 and 512, with a mean of 5 db. and no significant overmasking for frequencies above this. This is comparable to the effect noted in normals (Fig. 3).

Figure 7 shows the absolute effectiveness of masking at 80 db. in relation to the capacity of the machine.

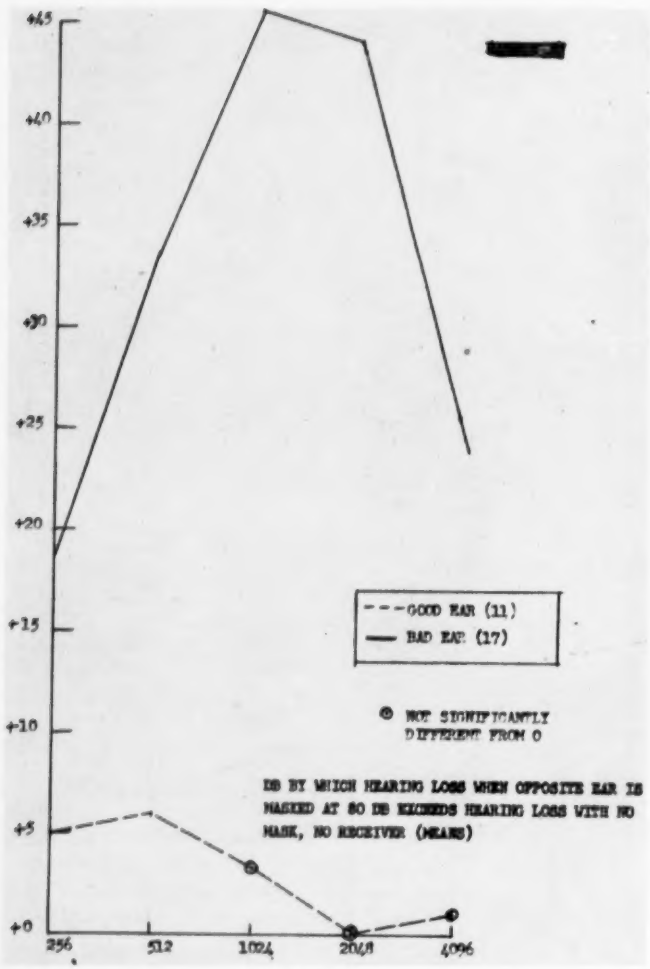

Figure 6

"Ineffective" Masking

When the good ear of a person is masked, the apparent bone-conduction hearing in the bad ear is not immediately reduced; that is, some of the mask is "ineffective." The magnitude of the ineffective masking was estimated in the following manner: When the masking intensity was sufficient to produce a greater hearing loss than the no-mask, no-receiver loss, the difference between no-mask, no-receiver loss and the loss at that intensity was taken as a measure of the "effective masking." The difference between total masking intensity and "effective masking" was taken as an estimate of "ineffective masking."

For example:

No-mask, no-receiver hearing loss=10 db. at 256 cps.

Opposite ear masked at		
	50 db.	−5
	60 db.	10
	70 db.	20
	80 db.	30

At a mask of 70 db. the loss was 10 db. above the no-mask, no-receiver loss. This means that 10 db. of masking was effective and 70-10, or 60 db. was ineffective.

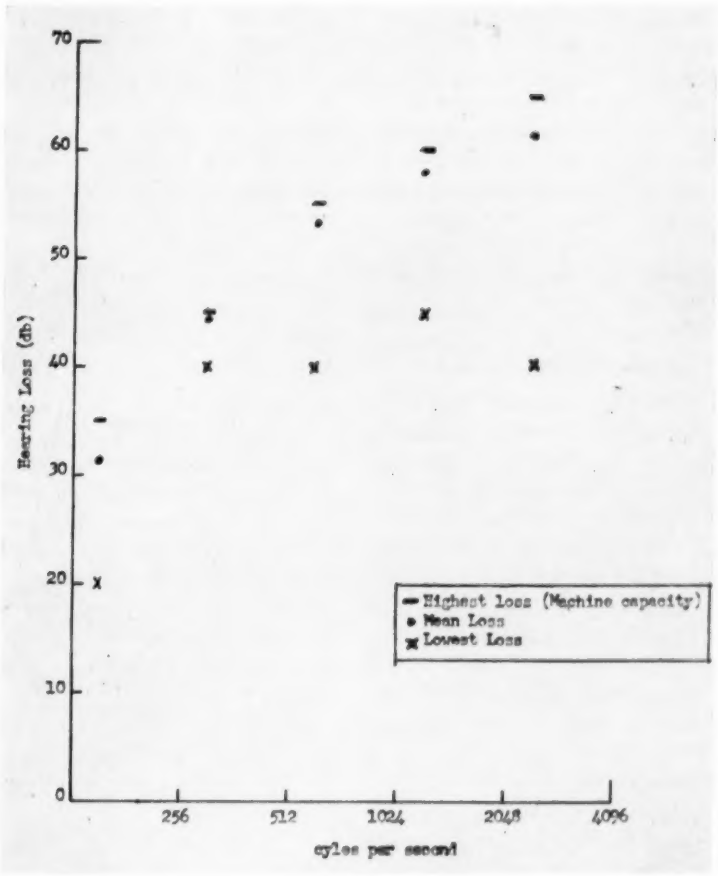

Figure 7

In this group of unilateral-deaf cases, ineffective mask re normal threshold was as follows:

Frequency	Ineffective Mask (Db.)
256	52
512	36
1024	31
2048	34
4096	39

Differences among 512 to 4096 cps were neither clinically important nor statistically significant. At 256 cps, however, the ineffective mask was highest for 13 of the 17 patients and was tied for first place in one more case. This is statistically highly significant, and we may conclude that ineffective masking is significantly higher at 256 cps than at any other frequency.

In bone-conduction measurements the transition between auditory sense and vibration sense must be considered in evaluating results. When the bone-conduction oscillator is placed over the tibia of most observers, they will indicate vibratory sensation at a level of about 35 db. for frequency 250 and 50 db. for frequency 500. Likewise, when patients with total deafness by air conduction are tested by bone conduction there is usually residual "hearing" for frequency 256 and often for 512. This is most likely due to vibratory sensations unrelated to the inner ear. In determining effectiveness of masking this should be borne in mind.

When the ear to be masked has a conductive deafness, masking is much less effective. In fact, 80 db. not only fails to eliminate hearing by bone conduction on the opposite side but it is relatively ineffective in lowering the threshold of this "borrowed" bone conduction. Data demonstrating this will be the subject of a later paper. It should be noted that the subjects were not trained listeners, so the results should have clinical application.

Summary

Placing a receiver over the ear to be masked causes an enhancement of hearing by bone conduction for frequencies 256 and 512 as measured at the opposite ear. This enhancement is about 15 db. for 256 and 10 db. for 512. There is no significant change in frequencies 1024 through 4096 (Fig. 3).

Receiver occlusion of the good ear in unilateral complete deafness causes a similar change except for frequency 4096. At this frequency there is a reduction of 15 db., indicating that at this frequency normal ears are hearing by air conduction during bone-conduction testing (Fig. 5).

Bone conduction measured at the deaf ear in unilateral deafness is not significantly different for frequencies 256, 1024, and 2048 from that measured at the good ear in unilateral deafness. For frequencies 512 and 4096 there is a loss of 10 and 15 db., respectively (Fig. 5).

Masking the deaf ear at 80 db. re normal threshold (100 db. re 0.0002 dyne per square centimeter) causes an overmask of about 5 db. for frequencies 256 and 512 and no significant change for frequencies 1024 through 4096 in unilaterally deaf persons. Similar overmasking is shown when one normal ear is masked at this intensity while testing the other (Figs. 3 and 6).

If the total masking intensity is related to its effectiveness in eliminating crossed hearing, the total may be divided into "effective" and "ineffective" components. Masking is least effective for frequency 256 cps, 50 db. re normal threshold of the total being without effect. For the other frequencies the ineffective portion of the mask is 35 db. re normal threshold (50 db. re 0.0002 dyne per square centimeter) (Fig. 6).

Eighty decibels of white noise re normal threshold (100 db. re 0.0002 dyne per square centimeter) makes possible bone-conduction measurements free from crossed hearing close to the audiometer limits (Fig. 7).

Conclusions

1. Eighty decibels of white-noise masking re normal threshold (100 db. re 0.0002 dyne per square centimeter) is the loudest subjectively acceptable level of masking for routine clinical use in both air- and bone-conduction measurements. This corresponds to a dial setting of 60 on Audivox and 80 on Sonotone machines equipped with random noise.

2. This level produces an overmasking of about 5 db. by bone conduction for frequencies 256 and 512 only and does not affect other frequencies.

3. It is more difficult to eliminate frequency 256 by masking than others usually tested. To produce equivalent masking about 15 db. more masking is required than for other frequencies.

4. For the speech frequencies, 30-35 db. of mask re normal threshold (50 db. re 0.0002 dyne per square centimeter) is ineffective in eliminating crossed hearing by bone conduction.

5. The above statements apply only when the ear to be masked has normal or near-normal hearing. It is probable that they also apply to ears with nonrecruiting perceptive deafness but not to ears with conductive deafness.

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Additional Data on Bone-Conduction Shift When the External Auditory Meatuses Are Occluded

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That occlusion of the external auditory meatus results in increased sensitivity for bone-conducted sound was known as far back as 1827, when Wheatstone noted that a tuning fork placed on any part of the head sounded louder if the ear canals were closed. Several investigations which verified this finding followed. The article by Kelly and Reger [5] gives an account of these earlier studies.

More recently further research has been done on this phenomenon of increased bone-conduction sensitivity. For example, Pohlman and Krantz [6] observed the effect of occlusion on bone-conduction thresholds as a function of the frequency of the sound stimulus. They showed that closing both ears with wax lowered the thresholds for frequencies 128-1024 cps, as shown in Table 1. At 2048 cps the effect of occlusion was found to be negligible.

Accepted for publication Nov. 13, 1956.

Mario Debole and Jack Curtiss assisted in the collection of data for this study.

Associate Professor of Clinical Speech (Dr. Siegenthaler) and Graduate Research Fellow (Mr. Cohen), The Pennsylvania State University. From the Virginia Society for Crippled Children and Adults (Mr. Rhodes).

Kelly and Reger [5] reported the effects of occlusion on the thresholds of 26 normal subjects for frequencies 64 to 8192 cps. All testing was done in a sound-proof room, with measurements taken when the ear canals were open and when the canals were filled with cotton-petrolatum (Vaseline) plugs. It was found that closing the canals improved the bone-conduction thresholds for frequencies 64 to 1024 by as much as 27 db. (see Table 1). Frequencies 2048 and above showed no significant shifts.

In 1947 Sullivan, Gotlieb, and Hodges [7] demonstrated that occlusion shifts occurred for normal and perceptively deaf ears but not for ears with conductive loss. Bone-conduction thresholds on the better ears of subjects from each of these diagnostic categories were obtained with the ear canals open, and closed with wet cotton plugs. Occlusion shift for the normal and the perceptive deaf ears was the same, and averaged 17 db. for frequencies 250 to 2000 cps (see Table 1). The conductive cases, however, showed no significant change in threshold upon closing the meatus.

Two major explanations have been advanced to account for these findings. Hallpike [3] and Dean [2] suggested that the masking

TABLE 1.—*Bone-Conduction Threshold Shifts (in Decibels) upon Occlusion of External Auditory Meatuses as Reported in Various Studies*

Experimenter		Frequency								
		64	125 (128)	250 (256)	500 (512)	1000 (1024)	2000 (2048)	3000	4000 (4096)	8000 (8192)
Pohlman and Krantz [6]		x	19	21	23	12	2	x	x	x
Kelley and Reger [5]	*	24	27	23	18	14	1	x	0	0
	†	25	26	24	20	17	3	x	1	1
Sullivan et al.[7]	‡	x	13	20	23	18	9	x	3	1
Present study	*	x	17	23	20	11	x	7	x	5

The meanings of the symbols used are as follows: *, with bone-conduction oscillator in forehead midline; †, with bone-conduction oscillator on mastoid; ‡, monaural occlusion only, oscillator on mastoid; x, not tested.

effect of environmental noise produced the differences in threshold under occluded and nonoccluded conditions: When testing, occlusion of the ear canals eliminates or reduces the noise intensity and gives rise to better thresholds. That the presence of environmental noises causes threshold shift during clinical testing is a common clinical observation; when the noises are eliminated or reduced thresholds improve.[1]

A second explanation for the effect of occlusion upon bone-conduction sensitivity was given by Watson and Gales.[8] Their proposal was that with bone-conduction stimulation vibration of the osseous portion of the external auditory meatus sets up pressure variations in the closed air lock formed in the meatus by the occlusion. These pressure variations act upon the eardrum, are transmitted to the inner ear by the conduction apparatus of the middle ear, and reinforce the direct bone-conduction hearing. Therefore, less stimulus intensity is necessary for a bone-conduction threshold with the canal occluded than with the canal open. Watson and Gales measured bone-conduction thresholds with various volume enclosures fitted to the ear. They expected that pressure variations delivered to the tympanic membrane in the presence of large volumes of air would be less than for small volumes of air and that the air-conduction effect would be decreased. This effect was demonstrated when the bone-conduction shift diminished and finally disappeared as the enclosure was made larger. Watson and Gales reasoned that the added air-conduction effect is present only for the lower frequencies because the skin and other tissues surrounding the external meatus are ineffective in transmitting higher frequencies of vibration and so do not set up pressure fluctuations in the closed air lock.

The finding of Sullivan et al.[7] that conductive hearing-loss cases show no occlusion shifts strongly indicates the importance of the conductive apparatus to the shift phenomenon. Their findings can be interpreted to support both of the above explanations of the occlusion shift. In the presence of a middle-ear lesion noise would not be heard well and it would be less effective in masking bone-conducted tones. Thus occlusion of the ear would cause little additional reduction in effective masking noise, and the explanation for the occlusion shift by Hallpike and Dean is supported. However, an operant middle ear is necessary for the sound induced in the closed cavity of the meatus to reinforce bone-conducted sounds, according to the explanation by Watson and Gales. If the middle ear is not operant, as in a conductive loss of hearing, the sound reinforcement would not reach the inner ear.

In the present study a further investigation of the occlusion effect on bone-conduction threshold was made. A sound-isolated, anechoic chamber was used, care was taken to standardize occlusion of the meatus, and the effect of induced environmental noise was considered.

Procedure

Occlusion of the external auditory meatus was accomplished by a vented plaster of Paris cast. The cast was made by first inserting a cotton wad 2 mm. into the meatus. A thread attached to the cotton was drawn through a plastic tube (insulation from No. 20 hook-up wire). Plaster of Paris was poured around the tube into the meatus, concha, and anterior segment of the scaphoid fossa and allowed to set. Upon removal of the cast the cotton, thread, and excess tube were removed, and the cast was trimmed so that its mass was 9 gm. Casts were made for both ears of four young adult male subjects with normal hearing. For the ears-occluded stage of the experimental testing (both ears occluded) the conchae of a subject were coated with petrolatum and the casts were inserted; pieces of No. 20 solid hook-up wire were inserted about 5 mm. into the plastic tubes after the casts were in place. This procedure of venting the casts was followed to reduce the possibility of forming an abnormally high air-pressure lock within the meatus.

An anechoic chamber and associated control room were used for testing. The subject was seated in the chamber 6 ft. from an Electro-Voice SP8B 8-in. speaker (frequency response range 35-13,000 cps) in a suitable enclosure. A Western Electric 700A bone-conduction oscillator was placed on the midline of the forehead immediately above the brow line. Oscillator pressure was

standardized with an elastic headband requiring a pull of 400 gm. to disengage the oscillator 5 mm. from the forehead. The output from a Hewlett-Packard 201C signal generator was fed through a T-pad (controlled by the subject) to the bone-conduction oscillator. A white-noise generator drove the speaker to provide controlled intensity environmental noise. A Ballantine 310V voltmeter was used to measure voltage to the speaker and bone-conduction oscillator. The method of adjustment was used for threshold finding; each threshold was the mean of a descending and an ascending trial. Thresholds were obtained with ears open and ears occluded for the broad-band white noise (air conduction in a field) and for bone conduction at frequencies of 125, 250, 500, 1000, 3000, and 8000 cps under various conditions of noise. The noise conditions were 0, 20, and 70 db. noise.* The order of test conditions was systematically rotated among the subjects.

Results

The over-all attenuation of the earplugs on air-borne broad-band white noise was estimated by computing decibel ratios between the ears-open and ears-occluded noise threshold voltages at the loudspeaker. The median decibel attenuation effect of the plugs for the four subjects was 29 db.

Table 2 shows the decibel improvement for bone-conduction thresholds for the frequencies tested under the various noise conditions when the meatuses were occluded. In as much as white noise of over-all S.P.L. levels less than about 30 db. has negligible masking on pure tones,[4] the 20 db. noise-condition data differs little from the 0 db. noise-condition data. (The mean threshold over all frequencies, ears open, in 0 db. noise was 2.5 db. more intense than was the mean threshold over all frequencies, ears open, in 20 db. noise; these threshold values are not shown in Table 2.) The Median-column values of Parts A and B of Table 2 are estimates of the occlusion effect on bone-conduction thresholds.

By considering the 70 db. noise-condition data, a third estimate of the occlusion effect was obtained. Column A of Table 3 indicates the median differences in thresholds between 0 and 70 db. noise conditions with ears open; i. e., it indicates the obtained masking of 70 db. noise. Column B indicates median

* The noise generator-speaker circuit was turned off for the 0 db. noise condition. The 70 db. noise condition was obtained by placing a sound-pressure meter with C scale setting in place of the subject's head and adjusting the noise output of the speaker to 70 db. S. P. L.; the 20 db. noise condition was obtained by attenuating 50 db.

TABLE 2—*Decibel Change in Bone-Conduction Thresholds upon Occlusion of External Meatuses*

Frequency	Subject 1	Subject 2	Subject 3	Subject 4	Mdn.
		A. 0 Db. Noise Condition			
125	19.7	10.2	20.1	18.6	19
250	19.3	27.3	22.4	23.2	23
500	16.1	23.9	15.4	9.9	16
1000	13.3	19.8	3.9	12.9	13
3000	−3.5	16.5	6.3	6.9	7
8000	9.2	0.4	5.8	7.1	6
		B. 20 Db. Noise Condition			
125	12.0	9.4	25.8	21.8	17
250	17.0	39.3	20.1	25.3	23
500	18.0	27.1	21.8	23.0	22
1000	13.0	26.9	10.1	4.7	12
3000	−1.7	4.5	17.4	15.0	10
8000	−2.8	−2.2	0.3	−3.1	−2
		C. 70 Db. Noise Condition			
125	4.9	32.9	21.0	22.7	22
250	19.0	33.8	31.5	32.3	32
500	31.3	29.0	21.9	23.0	26
1000	24.0	26.0	30.2	28.9	28
3000	12.6	29.2	22.5	22.2	22
8000	23.5	27.6	22.8	18.6	23

Note: A minus sign preceding a number indicates that the threshold was more acute with ears open.

TABLE 3.—*Estimates of Occlusion Effect Obtained from the Seventy Decibel Noise-Condition Data*

Freq.	A Mdn. Threshold Shift Between 0 and 70 Db. Noise, Ears Open	B Mdn. Threshold Shift Between 0 and 70 Db. Noise, Ears Occluded	C Change in Masking Due to Reduction of Noise by Earplugs	D Mdn. Obtained Difference Between Ears Open and Ears Occluded in 70 Db. Noise	E Residual Not Due to Masking, i.e., Due to Occlusion
125	8	1	7	22	15
250	23	13	10	32	22
500	24	20	4	26	22
1000	35	16	19	28	9
3000	42	24	18	22	4
8000	25	12	13	23	10

differences in thresholds for the same noise conditions but with ears occluded; i. e., it indicates the obtained masking of the 70 db. noise as attenuated by about 29 db. due to earplug insertion. Substracting the values of B from those of A indicates the change in the masking effect due to earplug insertion; these values are indicated in Column C. If all of the threshold shift obtained between ears open and ears closed in 70 db. noise were due to attenuation of masking noise by the earplugs, Column C of Table 3 would coincide with Column D of Table 3. Column D of Table 3 and the Median column of Table 2, Part C, are the same data: the obtained median threshold shifts between ears open and ears occluded in 70 db. noise. The extent to which columns C and D of Table 3 do not agree is an indication of threshold shift not due to reduction of masking but due to some other effect, namely, an occlusion shift. Column E of Table 3 is the residual obtained by removing the threshold shift due to reduction in masking noise from the total threshold shift in 70 db. noise when ear canals were occluded, and is a third estimate of the effect on bone-conduction thresholds of occluding the external meatuses. (Upon casual inspection there may appear to be considerable variation among the three estimates of the occlusion effect. For example, at 8000 cps the estimates cover a range of 12 db. However, for 8000 cps and the other frequencies tested the ranges were of the same order as found among and within individual subjects, as shown in Table 2.)

By averaging the three estimates of the occlusion effect for each frequency a final best estimate from the present experiment is obtained as to the magnitude of the effect of occlusion of the external auditory meatus on bone-conduction thresholds at various frequencies. The values are indicated in the bottom row of Table 1.

Comment

That occlusion of the external meatus does produce a change in the obtained threshold (less stimulus intensity required to reach threshold) has been demonstrated. In the past, two explanations for the effect have been given: Occlusion reduces the masking effect of environmental noise, and occlusion causes the walls of the meatus to radiate supplementary sound waves into the meatus cavity to reinforce by air conduction the hearing of tones by bone conduction. That noise causes elevation of threshold is known. However, occluding the meatus does more than reduce interfering noise. The present and other experiments [5,7] demonstrated the occlusion effect in very quiet environments, and the present experiment showed a residual occlusion effect when the masking noise was accounted for. Thus the explanation that occluding the external meatus changes threshold because of attenuation of environmental noise must be rejected as the sole explanation of the effect. The present data do not lend themselves to testing the proposition that the increased acuity upon occlusion is due to sound radiation from the walls of the meatus.

Two clinical applications of increased bone conduction with occlusion of the external meatus are indicated. The first is that while giving a bone-conduction threshold test in a

noise environment an audiometric technician may be tempted to have the patient occlude his meatus. Although occlusion would reduce the undesirable masking of the noise, it would produce a spuriously high bone-conduction threshold. Therefore, the procedure is not to be recommended. However, there is the possibility that if a standard occlusion can be used and if the occlusion effect can be quantified precisely, an obtained occluded bone-conduction threshold could be corrected for the occlusion effect. A second clinical application of the occlusion effect may be that of providing certain hearing-aid users with devices to occlude the ears. Specifically, among the users of aids there are some who find it necessary to wear a bone-conduction receiver. Because of the comparatively poor output of bone-conduction hearing-aid oscillators, the occlusion effect might be put to use to improve the perception of some frequencies.

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A New Concept in Auditory Screening

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I. Introduction

The need for rapid auditory screening tests to measure the hearing of large numbers of persons is more urgent today than at any time in the history of the field of audition. The interest in conservation of hearing of school children and of military and industrial personnel has aroused an unprecedented interest in the measurement of hearing. This interest has stimulated research workers to attempt new, quick ways of identifying persons who may have a significant hearing loss.

There are two basically different methods currently used to measure hearing; one gives a record of the auditory threshold, and the other screens at fixed intensity levels and gives only pass or fail results. Either of these methods, as currently applied, is too time-consuming to satisfy the requirements of rapid testing of large groups. To see why this is so, let us consider the two methods more fully.

Measurements of the auditory threshold are obtained with either a manually operated audiometer or an automatic audiometer. The automatic equipment may be self-recording, and it may be adapted for either individual or group testing. When persons are tested singly no saving in test time is accomplished by the use of automatic equipment, but when group tests are given several persons may be tested in the time normally required for one. Threshold measurements require several minutes for completion, and if large numbers of persons are to be tested in reasonably short time periods group-testing methods must be used. Even then, threshold audiometry cannot meet the current demands for rapid auditory testing.

Screening tests also may be given individually or in groups. The individual tests are made by setting the attenuator dial of an audiometer at 15 or 20 db. and recording a pass or fail response at each frequency. This method is known as the sweep-check method of screening. Individual sweep-check screening tests may be completed in a minute or two. Group screening tests are made in the same manner as individual tests but with several earphones connected to the audiometer output. The number of earphones used varies from 5 to 50, according to the user's needs and preferences. Screening equipment may be either manual or automatic.

The first attempts to speed up the process of audiometric testing adapted existing equipment and tests to group audiometry. The question now is whether these group techniques can be further adapted to meet the requirements of rapid testing of very large groups or whether a new type of test must be developed.

II. Group Testing as a Possible Answer to the Need for Rapid Testing Techniques

We have found that group tests are not a satisfactory answer to the need for rapid testing, largely because group-testing techniques are not generally applicable. Consider the use of these techniques in the three groups of persons primarily concerned with large-scale auditory testing: school children, industrial personnel, and military personnel.

School programs are designed to divide the children into two groups as far as their hearing is concerned: (1) those who hear (at levels of 15 or 20 db.) all the standard

Accepted for publication April 8, 1957.

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frequencies tested by accepted screening audiometers and (2) those who fail to hear one or more of the frequencies at the predetermined screening level. Children who fail to hear all the screening tones are then tested by threshold methods and referred for medical examination if necessary. Group testing of any kind is particularly well suited to school testing programs. School children are readily available at most times during the school day, and they may be tested in groups without any special difficulty.

Military and industrial conditions, on the other hand, are unfavorable to group testing. Before employment in industry or before induction into military service, prospective employees or inductees are given auditory tests as part of a general medical examination. Under these circumstances testees are not readily available in groups. At later times, when inductees or employees may be working together in groups, it is still impractical to try to test them in groups. It would be highly impractical, for example, to remove several men at one time from an assembly-line operation.

Group testing has one important general disadvantage also, namely, a large and exceptionally quiet room must be used for testing. Such a room is frequently difficult, if not impossible, to find. For this reason more than any other, most school systems use individual sweep-check tests, with the result that each child can be tested only once in three or four years because of insufficient time and personnel.

III. Search for a Better Method of Rapid Auditory Testing

It is obvious that group techniques are impractical in industrial or military situations. Yet the need for rapid testing of hearing of large numbers of persons in industry and in the armed forces is urgent, and some type of rapid, individual, pass-fail test must be provided to meet their requirements.

The many different test requirements and the various criteria for disposition of persons tested make it necessary to devise test procedures that can be adapted easily to different situations. The needs of the three groups primarily interested in rapid auditory testing are described briefly below.

As was stated earlier, school programs require that all children be given a pass-fail screening test and that those who fail be given threshold tests and referred to a physician for examination if necessary. Special difficulties commonly encountered in giving auditory tests to younger children are fatigue, boredom, and resulting inattention.

Industry's requirements are quite different from those of the school program. Industrial testing includes both preplacement threshold tests and follow-up tests. Preplacement tests give reference or baseline audiograms that are used for workmen's compensation and for hearing conservation needs. These threshold tests are air-conduction tests made in the usual manner and at the time of initial employment. Follow-up tests serve to check the status of employees' hearing and are made primarily to detect shifts from the threshold values recorded in the baseline audiogram. The first follow-up test is usually made some 90 days after employment in order to detect highly susceptible ears. Subsequent follow-up tests are made routinely once a year. Making a preplacement threshold audiogram is part of the routine preemployment medical examination, and as such it presents no special problems. Follow-up tests, on the other hand, frequently cause difficulty because the test may require employees to be away from their work long enough to interfere seriously with work schedules.

Military testing also is of two types: (1) induction tests which may be the pass-fail type and (2) classification tests which must be threshold tests. Induction tests are made preferably on an individual basis, and they must be rapid tests. A screening-type test is admirably suited for use at induction stations, but current screening methods re-

quire too much time and too many personnel to be of optimum efficiency.

In school testing programs, industrial follow-up tests, and military induction examinations, it is necessary to know only that a person's hearing is at least as good as, or is worse than, some predetermined level. This indicates that a screening-type test is adequate for most large-scale rapid tests. The problem is to find a reasonably accurate and dependable method of screening that will provide the desired information about large numbers of persons in a very short time. The use of single-stimulus screening tests was investigated first. Bursts of noise, clicks, and samples of speech were studied. None of these stimuli was found to be satisfactory, and we were forced to look elsewhere for possible modifications of existing screening techniques.

IV. New Concept of Pure-Tone Auditory Screening Tests

As large amounts of auditory data accumulated in our files it became apparent to us that the thresholds at 4000 cps were, in many records, higher than the thresholds at other frequencies. To check whether or not this was generally true we analyzed some 5000 audiometric records which were drawn from the record files of industrial workers, the general population, and office patients. An additional 1500 audiometric records of school children were also studied. A brief report of the results of these analyses is given below.

Eleven hundred twenty-eight audiograms were selected at random from our office files. For these 1128 patients the cause of hearing loss was diagnosed as follows: otosclerosis in 34.1%, presbycusis in 16.6%, and miscellaneous causes in 49.3% (Table 1). Upon analysis 98.4% of all records that showed a 15 db. loss at 4000 cps in either ear showed no more than 15 db. loss at any lower frequency (Table 2). A similar study of the records of 1749 males whose hearing was measured during the 1954 Wisconsin State Fair Hearing Survey gave almost the same results (Table 3). A study of the records of 1971 male aircraft workers showed that 99.2% had no more loss at any lower frequency than the loss recorded for 4000 cps (Table 3).

A somewhat different study was made of 1500 school children who were screened at 4000 cps at 15 db. and then screened again by the standard sweep-check method. (The sweep-check method screens at each of five frequencies at a specified level, in this case 15 db.) All who failed by either method were tested in the usual threshold manner. When the children were screened at 4000 cps, 94.4% passed. When they were screened with the sweep-check method, 93.3% passed. The single-frequency screening test was, therefore, 98.5% as accurate as the sweep-check test used under similar conditions and with the same children as subjects (Table 3).

TABLE 1.—*Office Sample Used for Checking Validity of Screening with 4000 Cps Only*

Diagnosis	Per Cent of Total
Otosclerosis	34.1
Presbycusis	16.6
Miscellaneous	49.3

Number of patients was 1128.

TABLE 2.—*Analysis of Office Sample (Table 1)*

	Screening Frequency	Number of Tests	Per Cent Correct
One ear	4000	2256	97.27
Both ears	4000	1128	98.24
Both ears	2000 & 4000	1128	99.02

TABLE 3.—*Analysis of Samples Used to Check Validity of Screening with 4000 CPS Only*

Sample	% Total 15 Db. or Less at 4000 (Group A)	% Total 20 Db. or Less at 4000 (Group B)	% Group A 15 Db. or Less at 500	1000	2000	8000
School (N = 1500)	93.7		99.7	99.7	99.8	99.2
Industrial (N = 1971)		95.8				
General (N = 1749)	28.1			98.2	97.4	

Sample	% Group B 20 Db. or Less at 1000	2000	% Total Passed by Sweep Test at 15 Db.	% Total Passed by 4000 at 15 Db.
School (N = 1500)			93.9	94.3
Industrial (N = 1971)	99.3	99.2		

These analyses show that for appropriate groups, one can quite accurately predict that losses at any standard test frequency will not be more than the loss at 4000 cps. On the basis of these findings we feel certain that when screening audiometry can be used the single-frequency test will accomplish the same results as any other screening method, and in much less time.

The study on the 1500 school children was made with an instrument built by A. M. Brooks Company, of Los Angeles. This instrument, known as the Oto-Chek, is a simple, battery-powered transistorized screening audiometer. There are two basic models of the Oto-Chek: a single-frequency screener and a double-frequency screener. One is designed to test hearing at 4000 cps, the other at 2000 and 4000 cps. Either model may be obtained with single or double earphones, and with output levels of 15 and 30 db. or 20, 35, and 50 db. The frequencies and levels are fixed. The earphones are energized by means of push buttons which are labeled in decibels of hearing loss according to the output level. When binaural earphones are used, the live earphone is selected by a rotating two-position switch. The entire circuit is housed within a metal box measuring 5½×4×2 in. The Oto-Chek is powered by a Mallory mercury cell-type battery and energizes a dynamic-type earphone. The earphone is coupled to the ear by a standard MX-41/AR type sponge rubber cushion. The entire instrument weighs between 1¼ and 1½ lb., depending on whether there are one or two earphones.

V. Advantages of Single- and Double-Frequency Screening Tests

Single- and double-frequency screening tests have many advantages when compared with other screening methods. For example, screening at 4000 cps makes it possible to test hearing in ordinarily quiet rooms, such as quiet offices, first-aid rooms, rest rooms, and treatment rooms. Ambient noise will not influence test results unless the noise level is considerably higher than that of the average quiet office. The single- and double-frequency tests require only a few seconds to complete, thereby making individual testing as rapid as group testing with the older methods. School children, even the younger ones, do not become fatigued and inattentive before the test is completed. The tests are simple to give and therefore do not require trained personnel. Additional advantages are that the equipment is relatively inexpensive, light in weight, battery-operated, and nearly indestructible.

The single- and double-frequency screening tests are suitable for use with school children, industrial employees, and inductees. In addition, because the method is simple and the equipment inexpensive, these screening tests may be used in many situations where tests are not now being made or where testing programs are inadequate because of lack of personnel, improper testing environments, insufficient funds, or objections to spending the time necessary for making tests according to current techniques.

For some time we have urged otolaryngologists to test the hearing of each patient they see, and we have tried to interest general practitioners, internists, and pediatricians in testing the hearing of many of their patients. We believe that the single-frequency test will make such general testing practical. These physicians need to know only that a patient's hearing is normal or is abnormal enough to need further attention. Information of this kind is readily furnished by the single-frequency screening test.

School programs will be considerably enhanced when a single-frequency test is used: Many more children can be tested by the same personnel and in the same amount of time; ambient noise is less of a problem; lack of power outlets does not restrict the use of the testing equipment; more test instruments can be purchased from the same appropriations; nonaudiological personnel can give the tests, leaving the trained audiologists free to give more and better

threshold tests to the children who fail the screening tests.

The single-frequency screening test makes a practical program of follow-up tests available to industry for the first time. Instruments for making the follow-up tests can be placed at various points in the plant—in a quiet area near the time clock, for example. Here men can be tested quickly and accurately just before or just after punching their time cards. This procedure makes it unnecessary for employees to travel to and from the medical department for follow-up tests, thus saving many minutes of work time for each employee.

Few, if any, inductees are now tested for hearing defects. When a man is inducted into military service, he is medically examined on a production-line basis. Each part of the examination is made in less than a minute. Any current accurate hearing test takes considerably longer than one minute and would be a bottleneck in the examination program. The single-frequency screening test is particularly suitable for use with military personnel and would introduce into the induction examination for the first time an accurate auditory test.

VI. Summary

Screening audiometry has a definite place in school, military, and industrial testing programs. The usual screening methods are not completely suitable for any of these three situations, and the need for a new test was evident.

Considerable research with single stimuli, such as bursts of noise, clicks, and words, showed these to be unsatisfactory. Investigations of large numbers of audiograms demonstrated that in approximately 99% the hearing loss at 4000 cps was as great as, or greater than, the loss at any lower frequency. On the basis of this observation, several studies were conducted which confirmed this finding.

We therefore recommend that testing at 4000 cps be used as a screening test in schools, industry, the military forces, and in doctors' offices. Such a screening method has none of the disadvantages of other methods and many more advantages, for example:

1. Ordinary quiet rooms (offices, first-aid rooms, etc.) may be used for testing.

2. The test requires only a few seconds to complete, saving time and preventing fatigue.

3. The instrument is inexpensive, lightweight, and very durable.

111 N. Bonnie Brae St. (26).

Case Reports

Laryngeal Papillomata

A Surgical Technique for the Removal of Multiple Obstructive Recurrent Papillomata of the Larynx

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This is a follow-up report on a technique which was presented before the American Laryngological Association's annual meeting in March, 1955. At that time the discussion which followed did not indicate that much hope was held for the permanency of the good result obtained. It is now over three years since the operation was performed and the patient remains free of all evidence of any recurrence. It is for this reason that I am bringing to the attention of this symposium on laryngeal papillomata a review of the technique used.

Report of Case

A woman, aged 35, had a history of 14 hospital admissions for the removal of laryngeal papillomata via laryngoscopy since 1942.

The pathological reports of tissues removed were always laryngeal papillomata, with no evidence of malignant changes.

When first seen by me, the patient had dyspnea and the glottis was filled with growths hiding any view of the true or false cords. With the laryngoscope it was difficult to determine the exact origin of the growths. A drawing made from a photograph of an indirect view of the obstructed glottis as seen at that time is shown in Figure 1.

A tracheotomy was done on Feb. 17, 1954. Three weeks later the following procedure was carried out: A horizontal collar incision was made about 1 cm. above the tracheotomy stoma. The latter had been placed between the first and second rings of the trachea. The midline of the larynx was exposed. A typical fissure incision was made starting at the thyroid notch down through the periosteum and continuing as far down as the cricothyroid membrane. The periosteum was elevated and lateralized about ¼ in. over its midpart. With a circular electric saw, the midline

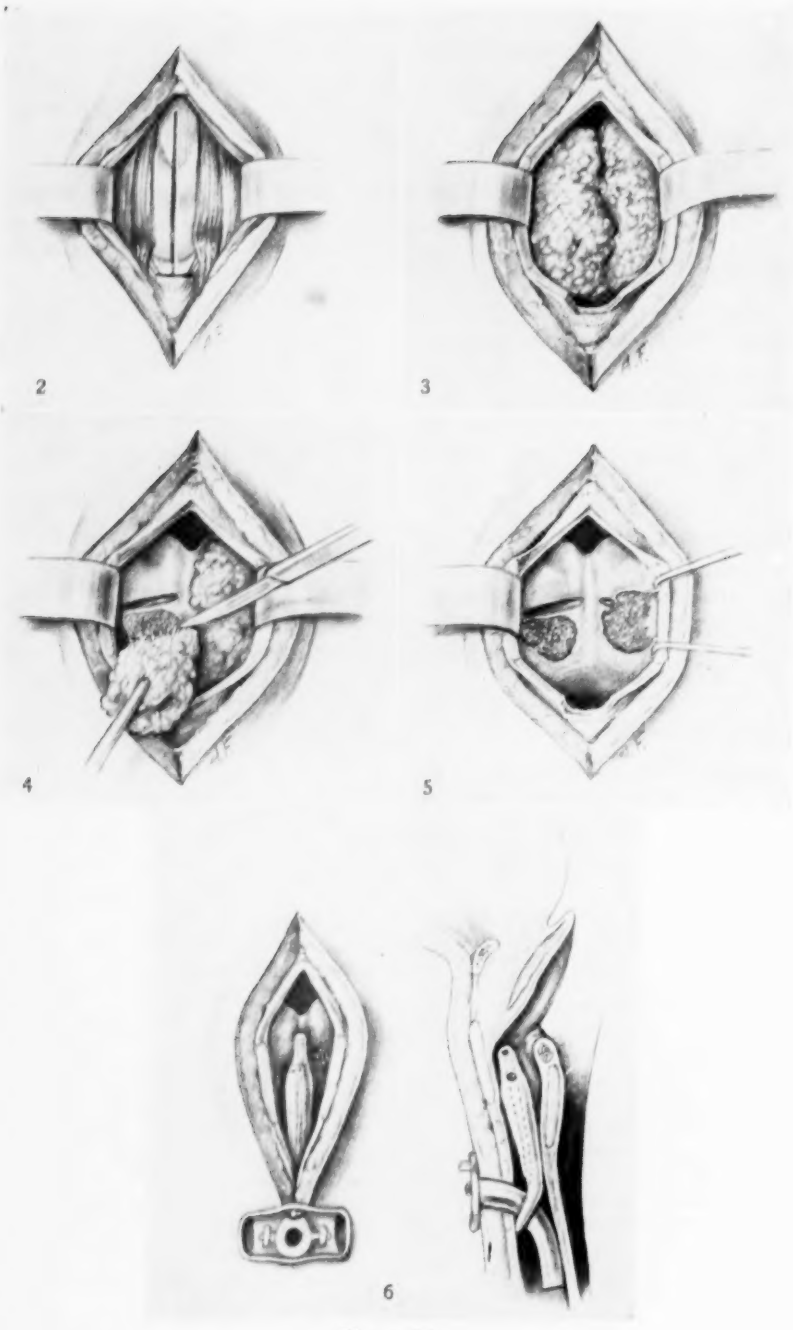
Accepted for publication April 8, 1957.

Figure 1

of the cartilage was cut through (Fig. 2). The alae were then retracted and a large polypoid mass exposed (Fig. 3). This mass measured 1×2 cm. in diameter. It appeared to be attached mainly to the right side of the larynx. The growth on the right was removed by submucosal resection of the mucosa over the anterior two-thirds of the right true cord, retaining intact submucosal tissues (Fig. 4). With this mass removed, the left side of the larynx was seen to have polypoid tissue involving an even wider area than on the right, though not mounded as high as that on the right side. The involved area on the left side was removed en bloc by elevating the periosteum on the inner side of the left thyroid ala, and removing both the true and false cords from the anterior commissure back to the vocal process, as shown in Figure 5. Bleeding was controlled with cautery.

An acrylic mold (Fig. 6) was then placed with the ring fitted over the tracheotomy tube to hold it in place.

The alae cartilages were brought together with Atraumatic chromic sutures; muscle layers were brought together with interrupted absorbable surg-



Figures 2-6

Figure 7

ical (gut) sutures. The cricothyroid membrane was sutured with fine absorbable surgical sutures. The skin was closed with interrupted Atraumatic Dermalon (skin and tension suture processed from nylon) without a drain.

Eight weeks later the acrylic mold was removed perorally. The glottis was found smooth and covered with normal-appearing mucosal lining. A drawing made from a photograph taken as an indirect view of the glottis four months after removal of the acrylic mold is shown in Figure 7.

The left cord area had no motion, but the right side had adductor function. The voice was whispered in character and was adequate for communication over the telephone. The airway was larger than normal. Sphincteric action of the upper part of the glottis remained active.

Comment

The use of the acrylic mold permitted mucosa to grow under conditions which desensitized the mucosa to the causal processes developing papillomata. This new mucosa is a thin, smooth layer with apparent ciliated activity. No crusting appeared at any time. This certainly has considerable advantage over the placement of skin grafts, with their tendency to redundant folds and greater thickness, which, in turn, makes for less of an airway. This type of procedure is not recommended for the juvenile undeveloped larynx.

Summary

A surgical technique via laryngofissure with the use of an acrylic mold is demonstrated for the treatment of those cases of multiple recurrent papillomatosis which develop glottic obstruction.

156 E. 37th St.

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Abstracts from Current Literature

Ear

CHRONIC ADHESIVE OTITIS MEDIA. J. P. J. MACNAUGHTON, J. Laryng. & Otol. 70:549 (Oct.) 1956.

A study of the literature reveals revival of interest in the subject of chronic adhesive otitis media since 1950. Of 5000 persons attending the Hearing Aid Clinic in Aberdeen Scotland, 30% were believed to have chronic adhesive otitis media. The etiology is based upon the formation of adhesions in the middle ear, caused by an infection of sufficient virulence to provoke a fibrinous exudate, which, in turn, must remain in the middle ear for sufficient time to organize. The mechanical and immunologic factors are discussed briefly. Pathologically the commonest sites for adhesions are the window niches, Prussak's space, and the epitympanum. The adhesions are most pronounced between the anterior arm of the stapes and the anterior and superior walls of the niche. In severe cases there are always adhesions in the round-window niche.

In the cases reviewed by MacNaughton, the criteria used for selection were a history of slowly developing deafness without pain or discharge, tympanic membranes showing pathologic changes without perforation, and deafness of the middle-ear type. In this series 36.7% were less than 15 years of age. There were about 20% in each decade from 20 to 50 years.

Treatment in the past has been limited largely to fenestration, with poor results. Microsurgery that is being developed holds promise of better results. The best treatment is prophylactic, consisting of adequate measures to establish and maintain middle-ear drainage plus antibacterial therapy during active attacks of otitis media.

LEJEUNE and STEVENSON, New Orleans

CHRONIC ADHESIVE OTITIS. TERENCE CAWTHORNE, J. Laryng. & Otol. 70:559 (Oct.) 1956.

Cawthorne included only cases that satisfy the following criteria in his discussion of chronic adhesive otitis media: history of former ear trouble and conductive deafness (often from an early age), combined with abnormalities of, but not deficiencies in, the tympanic membrane. He did not include cases with tympanic-membrane perforations, although the structures of the middle ear in some of these cases may actually be involved in a chronic adhesive process; and he excluded patients who have no hearing loss, in spite of the fact that often the tympanic membrane may demonstrate gross abnormalities suggestive of previous disease. On the basis of these criteria, he had only 22 cases of chronic adhesive otitis media out of 1541 patients seen by him with impaired hearing during the past three years. He expressed the opinion that chronic adhesive otitis deafness is not nearly as common as is generally believed. The deafness was not severe in his cases, the average loss in the speech frequencies being 45 db. He agreed with Polvogt and Perlman that gross adhesive changes in the middle ear are compatible with normal hearing in many instances. Differential diagnosis and prophylaxis are discussed briefly. Treatment is imperfect at the present time. Tympanoplasty may offer a solution. Fenestration has proved disappointing. The principal need at present is more thorough knowledge of chronic adhesive otitis.

LEJEUNE and STEVENSON, New Orleans.

BONY FIXATION OF THE STAPES DUE TO CHRONIC "ADHESIVE" OTITIS MEDIA: A CLINICO-PATHOLOGICAL STUDY. C. S. HALLPIKE and M. SPENCER HARRISON, J. Laryng. & Otol. 70:565 (Oct.) 1956.

This is the report of a case of unilateral conductive deafness which was studied clinically before death, and then studied pathologically at necropsy. Before death it was impossible to distinguish this case from clinical otosclerosis. The autopsy specimen revealed that the stapes had a normal footplate but that its neck and posterior crus were joined to the Fallopian aqueduct by fine bony ankylosis. Other indications were found in the middle ear to suggest an old chronic inflammatory process. Several questions are raised concerning the advisability of prefenestration examination of the stapes for exact diagnosis.

LEJEUNE and STEVENSON, New Orleans

STATISTICAL ANALYSIS OF THE STAPES MOBILIZATION PROCEDURE. CHARLES E. KINNEY, Laryngoscope 66:1339 (Oct.) 1956.

A questionnaire was sent to 14 leading otolaryngologists interested in the stapes-mobilization operation. The total number of operations was 1117. There was a successful result in 53% of the cases three to four weeks postoperatively and in 40% after six months. In general, the percentage of successful operations rose as the physicians gained experience. Some of the cases which ended in failure were later fenestrated. There was a successful result in 82%.

Most cases required 1-2 mm. of bone removed from the posterior canal wall. The use of audiometry during the operation was considered necessary by most.

Several methods were employed by the various physicians, including Rosen's original method and House's pneumatic hammer technique. Temporary acute otitis media was the only real complication. There were no facial palsies.

HITSCHLER, Philadelphia

THE VALUE OF AMNIOTIC MEMBRANE IN LINING THE MASTOID CAVITY. M. ORESKOVIC and Z. KEKIC, Rev. Laryng. (Bordeaux) 77:546 (May-June) 1956.

The authors have been using amniotic membrane in place of Thiersch grafts to line the mastoid cavities. While this material has been used for many years under different circumstances with varied success, the modification of the technique as proposed by the authors has produced excellent results. There are certain criteria necessary for success: 1. The material must be fresh. 2. Its serologic examination must be negative. 3. The blood group of the pregnant woman must be the same as that of the patient. The placenta must be obtained by expression after a normal delivery. This is delivered aseptically and placed in a sterile container. The graft must be used within six hours after its delivery. The authors do not recommend cold storage, since there may be material histologic changes in the membrane. When ready for use, a section of the membrane is cut out, making sure that there are no blemishes or veins present. The chorion is removed, and the section is placed in a solution of penicillin and streptomycin sulfate, preferably isotonic. This amniotic epithelium, when free and clear of chorion, is transparent, elastic, and resistant, and is much thinner than the skin graft of Thiersch. The graft is placed in the mastoid cavity, making sure that there are no air bubbles or blood between the graft and the bone. The fetal ectodermal surface should be toward the exterior. Tamponage of the graft in place is performed in the usual fashion. The tampons are left in place for 8 to 10 days following the operation. The advantages of this preparation are that the graft usually takes, the technique is simple, and because of the thinness of the graft, it can be used favorably in fenestration as well as in the normal mastoid operation.

PERSKY, Philadelphia

Larynx

PAPILLOMATA OF THE LARYNX. D. J. BRAIN, J. Laryng. & Otol. 70:614 (Nov.) 1956.

The author reviews the literature on papillomata of the larynx and gives his personal findings based on 21 cases treated at the University College Hospital during the past 15 years. He reports 6 cases of multiple papillomata occurring in children, and the other 15 cases include the noninvasive multiple or single papillomata occurring in adults. The theories of etiology are briefly discussed as are also the predisposing site, the spread, and the clinical features of this growth. His experience coincided with that of others in that the removal of multiple papillomata in children was usually followed by a quick recurrence. While various types of treatment are considered, the author offers nothing new or useful for the treatment of multiple papillomata of the larynx.

LEJEUNE and BEATROUS, New Orleans.

VOICE REHABILITATION VIA LARYNGEAL SURGERY AND SPEECH THERAPY. DEGRAAF WOODMAN and SHULAMITH KASTEIN, New York J. Med. 57:60 (Jan. 1) 1957.

The authors are affiliated with the Department of Otolaryngology, Presbyterian Hospital (New York), and the Vanderbilt Clinic. They present a case report of a woman, aged 38, who had "croup" and a tracheotomy in childhood. Although the tube was removed 11 days later, she was hoarse and remained so for two years. A physician diagnosed a laryngeal polyp, which he removed, but little or no improvement in voice followed. Another operation

was done, also with little improvement in the voice. A definite web was seen by direct tube laryngoscopy. The physician decided to do a thyrotomy and introduce a keel until healing was directly lateral. The keel was in place eight weeks, and then it was removed by external cutting. The expected improvement in voice was not entirely satisfactory; therefore, vocal exercises were given, with special emphasis on the "chewing method" of Froeschels as described by Weiss and Beebe. The patient was taught to "chew English rather than speak it." This was done with an open mouth. Letters, words, and sentences were spoken with a full voice, but without forcing or straining. The voice became clearer and louder; there was no fatigue or pain or discomfort. Diaphragmatic breathing, breath control, and avoidance of breath waste at the cords were practiced. Jaw shaking with phonation was also used. The result was satisfactory to the patient, and to her friends.

ABSTRACTER'S COMMENTS: In most cases removal of a web is insufficient if raw surfaces are allowed to fuse together again. The keel has its purpose in keeping these edges apart. Unilateral healing is accomplished.

I. W. VOORHEES, New York.

Nose

USE OF THE CHISEL IN RHINOPLASTY. S. COHEN, Eye, Ear, Nose & Throat Month. 7:435 (July) 1956.

The author prefers the chisel to the saw in performing the lateral osteotomy in a rhinoplasty. He feels that, if used properly, it achieves the desired results with the least disadvantages. The advantages and disadvantages of each instrument are listed and described in detail. The complications which may arise from faulty technique with the use of either the saw or the chisel are described. Cohen gives in detail the technique he utilizes for hump removal, mesial osteotomy, and lateral osteotomy. His article should be very useful for those rhinoplastic surgeons who would prefer to use the chisel.

JENNES, Waterbury, Conn.

USE OF THE SAW IN RHINOPLASTY. J. SAFIAN, Eye, Ear, Nose & Throat Month. 7:438 (July) 1956.

Safian uses the basic Joseph saw for both hump removal and lateral osteotomy in rhinoplasty. He considers the saw a very simple and easily controllable instrument. He feels that the difficulty that some men have in the use of the saw is due to their lack of control of the saw. It is important that the saws be held properly with exertion of force in the manner intended. Most of the difficulties attributed to use of the saw are due not to the instrument, but to the lack of the proper technique in its utilization. Too often instruments are discarded or condemned not because of any inherent fault of the instrument, but rather because the operator has not learned how to use it properly.

JENNES, Waterbury, Conn.

USE OF THE ELECTRIC SAW IN RHINOPLASTY. A. SELTZER, Eye, Ear, Nose & Throat Month. 7:440 (July) 1956.

The author describes an electric saw which he has devised for performing the lateral osteotomy in rhinoplasty. A special advantage of this saw is that the soft tissues are not cut through even when the saw moves at its greatest speed. This obviates the use of a guard. With this electric saw, the lateral osteotomy may be performed accurately in from five to eight seconds. If the operator takes longer than this length of time in utilization of this saw, it is better to remove it temporarily, cool it, and reinsert it, in order to avoid too much heating of the tissues. A guide has been provided to ensure greater accuracy in the placement of the saw cut, although it is not necessary from the point of view of safety.

ABSTRACTER'S COMMENT: In considering the use of the chisel, saw, or electric saw in rhinoplasty, and especially when one reads the opinions of men who firmly believe in the value of the instrument he commonly uses, one realizes that the type of instrument is less important than the technique observed by the surgeon. As in so many other fields of surgery where there is strong controversy as to which of several methods is best used to accomplish a stated purpose, good results may be observed in any of the methods when used properly, and poor results obtained in any of the methods when used improperly.

JENNES, Waterbury, Conn.

RHINOLOGY IN CHILDREN: RESUMÉ OF AND COMMENTS ON THE LITERATURE FOR 1955. D. E. S. WISHART, J. B. WHALEY, and W. B. WALLACE, Laryngoscope 66:1123 (Sept.) 1956.

The following abstract necessarily touches upon only a very few of the many well-covered subjects in this article.

In the treatment of the common cold and of nasal congestion, bed rest, moisture, and warmth are still considered valuable. Allergy, endocrine dysfunctions, and the psychosomatic element must also be considered. The use of thyroid, ovarian and testicular hormones, thiamine, and ascorbic acid may be advisable.

The use of Tyzine in infants caused some alarming soporific reactions. Use of a spray bottle is particularly dangerous because the dose cannot be regulated.

The natural cleansing of the nose is helpful in preventing sinusitis. In babies, the face-down position will aid in allowing the discharge to be snorted out. Vasoconstrictor drugs help if they are instilled about the middle turbinate. Antrostomy, antrum lavage, and small doses of triple sulfonamides daily all winter are sometimes required, especially in children. The relation between abdominal pain and sinusitis is discussed.

Carbazochrome (Adrenosem), parenteral estrogen, ascorbic acid (vitamin C), and vitamin K were all used successfully in reducing bleeding, operatively or otherwise. If the mentioned vitamins are administered, acetylsalicylic acid does not increase the bleeding tendency.

Bilateral choanal atresia in infants may cause asphyxia due to the fact that the tongue and soft tissues of the floor of the mouth cut off the airway. A simple method of surgical management of choanal atresia is described.

Many aspects of tonsillectomy are discussed. Several questions related to it are considered: Should there be preoperative analgesia? Should introtracheal or open-drop anesthesia be used? What effect has tonsillectomy on the future infection in the child? With regard to the latter, some evidence has been produced indicating that there is very little if any relationship. Surgical techniques are argued pro and con by various authors.

Most agree that much deafness can be cured or prevented by removal of the adenoids. Radium is also an adjunct, and little or no real evidence has been produced to indicate that carcinoma results.

Bulbar poliomyelitis is more frequent in the tonsillectomized children, even if the operation was performed years before the onset of poliomyelitis. However, these are the children who presumably have a poorer resistance to infection in general.

A review of nasal operations, fractures, and tumors concludes the review.

HITSCHLER, Philadelphia.

Pharynx

A SIMPLE METHOD TO REDUCE BLEEDING DURING TONSILLECTOMY. CAESAR N. ABU-JAUDEH, Laryngoscope 67:93 (Jan.) 1957.

Careful evaluation of the blood loss during 100 tonsillectomies was made. Before operation half of the patients were injected with 7-10 cc. of a saline-epinephrine solution, in a manner similar to that done for a local tonsillectomy.

The blood loss during operation in the injected cases averaged 20 cc., while in the uninjected cases it was 120 cc. The difference was considered significant.

HITSCHLER, Philadelphia.

Miscellaneous

NEWER DRUGS FOR THE RELIEF OF ALLERGIC DISEASES. CARL E. ARBESMAN, New York J. Med. 56:3678 (Dec. 1) 1956.

Arbesman reports from the Allergy Clinic, Buffalo General Hospital, and from the Departments of Medicine, Bacteriology, and Immunology of the University of Buffalo. Etiology comes first in any consideration of allergy. "Undoubtedly the most important addition to the therapeutic armamentarium . . . is the steroids." Those most favored are prednisone, prednisolone, the Spansules of aminophylline, and a few others. However, concerning the use of prednisone and prednisolone in allergic patients, of 139 treated, 19 had gastrointestinal symptoms. The conclusion was that the advantage of the use of these two over the use of other steroids is "less edema and sodium retention without sacrificing efficacy." Plimasin is a useful antihistamine when combined with a stimulant and is without

the undesirable feature of producing drowsiness. The use of Spansules of aminophylline was somewhat disappointing, especially in asthmatics, partly because of the gastrointestinal effects. The general conclusion is that while these newer remedies are not altogether satisfactory they point the way to further research, and the possible discovery of the ideal drug.

ABSTRACTER'S COMMENT: Patients often report drowsiness after taking antihistamines. Since so many drive automobiles, it is imperative to warn them that the use of these drugs may cause accidents. A railroad disaster some years ago brought out the fact that the engineer had taken antihistamines for "a cold" and that he felt drowsy in the cab before the accident. All workers in this field should stress somnolence as a cause of automobile accidents.

I. W. VOORHEES, New York.

A REVIEW OF HEADACHE, 1950-1955. ARNOLD P. FRIEDMAN and THEODORE J. C. VON STORCH, New York J. Med. 56:3883 (Dec. 15) 1956.

This is the 13th in a series of articles, under the editorship of Dr. Robert Turell, dealing with medical progress. It is stated that "headache is possibly the most frequent complaint of modern man." Hence, the literature contains a great deal of material concerning migraine, tension, etc. The present task is to review the fairly recent articles on headache and analyze the various statements and opinions concerning it. There is inevitably a strong vascular element in all headaches. The initial phase is constriction of blood vessels, followed by dilatation with temporary hypotonicity. With the use of extracranial devices for experimentation on blood vessels, it was found that there is an initial nonpainful vasoconstriction followed by a progressive dilatation in which the walls of the blood vessels become edematous, with subsequent pain. Major alterations in electrolytic balance are also found, and during an attack of vascular headache, there is not only loss of tone and marked distention of the large extracranial arteries but also dilatation and increased permeability of the arterioles and capillaries. It has been found that ergotamine tartrate produces a vascular constriction of the branches of the external carotid artery. It is this constrictor action which is responsible for interrupting the mechanism of headache. Reduction in the intensity of headache follows reduction in the lumen of the larger cranial arteries. Heredity is an important factor in migraine. There may be an inherent functional instability of the autonomic, endocrine, vascular, or enzyme systems. There is also a familial and environmental basis for headache as well as a hereditary one. Water electrolyte metabolism is also a factor to be considered. There are widespread fluctuations in fluid balance, as evidenced by swollen fingers and weight gain prior to headache, often accompanied by a state of hydration and diuresis. This field has not been as yet sufficiently explored, and the findings need to be substantiated. Examination of the pituitary-adrenal function in relation to migraine has been undertaken, and it was found in patients with migraine that the circulating eosinophiles fell by some 50% four hours after the stimulus (corticotropin or epinephrine) was given. A gonadal cause of headache, especially in women, has been suggested, but thus far there is no evidence to support this theory. Allergy may precipitate a headache, but the actual cause-and-effect mechanism has not been made clear to date. There is some support for the theory that sustained contraction of muscles, especially those of the head and neck, causes headache. Tension of muscles for long periods is associated with pain or ache in the upper cervical region, with extension to the face and forehead. Anatomically, the descending or spinal root of the trigeminus is thought to be involved. Psychologic causes of head pains seem definitely to be observed in many persons. Repressed hostility is demonstrated, and in children tantrums, phobias, nightmares, enuresis, anxiety, nail biting, etc., are common. An inturning of unpleasant circumstances upon the body occurs, with disturbed function of the sympathetic and endocrine systems. But there is no specific migraine type in children (or adults). Headaches associated with nasal, paranasal, and aural foci have been studied. The mucosa leading to and into the sinuses is often edematous, usually due to infection. However, sinus linings are said to be rather insensitive. Pain is often "referred" from a troubled area to a distant locus, for example, quinsy with earache. The first division of the fifth cranial nerve suffers from bacterial "insults." Postspinal puncture headache is common. While the patient is lying down there may be no pain, but upon sitting up headache is immediate. There is definite relation here to balanced fluid status.

In the treatment of headache it should be emphasized that we are dealing with a symptom rather than with a disease, although the disease may be hidden. An acute illness is often

associated with headache before, during, and after infections. A headache status may be acquired which persists in spite of all ordinary remedies. Migraine is now well controlled by ergotamine tartrate. This is a most useful drug, commonly administered as ergotamine with caffeine (Cafergot). However, it must be remembered that excessive use of ergot can produce headache! Rectal suppositories seem to work better than oral administration. The menopause is a time for headache. Thus Alvarez thought that induced menopause might stop headaches, but 50 out of 100 patients became decidedly worse. Medical management is highly important in all cases of cephalalgia; the importance of the patient-doctor relationship and environmental manipulation is emphasized. Diet must be regulated for each patient. The hours of exercise, sleep, and "recreation" must also be determined for each individual patient. Mention is made of injection of the stellate ganglion; it has caused numerous deaths! In general, surgery has not proved very effective except in special instances. Hypertensive headache is controlled by reducing the blood pressure and striving to hold it to a near-normal level. Of the ocular disorders, eyestrain is common, and is often relieved by fitting the patient with proper lenses.

ABSTRACTER'S COMMENT: This is an excellent literary *Arbeit* in medical research. However, it is disappointing to conclude that we have not as yet done all that we hoped to do in bringing relief to sufferers from headache. A word about injections of the stellate ganglion as first recommended by Sluder, he has had some marvelous results. I do not recall reports of death of his patients. My own experience with the application of epinephrine-cocaine paste to the ganglion has been quite satisfactory, although the treatment may have to be repeated rather often, and it does lose its effect. I have never put a needle into this area, and feel that it can be dangerous if inaccurately done.

I. W. VOORHEES, New York.

News and Comment

ANNOUNCEMENTS

Home Study Courses in Ophthalmology and Otolaryngology.—The 1957-1958 Home Study Courses in the basic sciences related to ophthalmology and otolaryngology, which are offered as a part of the educational program of the American Academy of Ophthalmology and Otolaryngology, will begin on Sept. 1 and continue for a period of 10 months. Detailed information and application forms can be secured from Dr. William L. Benedict, the executive secretary-treasurer of the Academy, 15 Second St. S. W., Rochester, Minn. Registrations should be completed before Aug. 15.

Contributions of Medical Literature to Korea to be Discontinued.—The American-Korean Foundation and the United States Army Medical Service have announced the discontinuation of their joint project of shipping medical books contributed by individual physicians, medical schools, hospitals, and state and local medical societies to Korea.

Books should not be sent to the Sharpe General Depot in California as in the past, for facilities no longer exist for packing and transshipping to Korea.

In making the announcement, Howard A. Rusk, M.D., President of the American-Korean Foundation, said, "The response of physicians and medical groups throughout the country for our appeal for books for Korean medical schools has been so generous that further contributions are not needed." As a result of this program, Dr. Rusk stated, over 77 tons, valued at $76,000, of medical texts, references, and periodicals have been shipped to Korea for distribution to Korean medical schools.

Directory of Otolaryngological Societies *

FOREIGN AND INTERNATIONAL

Canadian Otolaryngological Society
(Société Canadienne d'Otolaryngologie)

President: Dr. G. M. T. Hazen, 208 Canada Building, Saskatoon, Sask.
Secretary: Dr. G. A. Henry, 328 Medical Arts Building, Toronto.

Venezuela Otorhinolaryngology Society

President: Dr. Alfredo Celis Pérez.
Secretary: Dr. Jesús Miralles.

International Bronchoesophagological Society

President: Dr. Theodor Hünermann, Düsseldorf.
Secretary: Dr. Chevalier L. Jackson, 3401 N. Broad St., Philadelphia 40.

International College of Surgeons, Section of Ophthalmology and Otolaryngology

President: Dr. Henry M. Scheer, 522 W. End Ave., New York 24.
Secretary: Dr. Louis Savitt, 3402 W. Lawrence Ave., Chicago 25.
Place: Palmer House, Chicago. Time: Sept. 8-12, 1957.

International Congress of Audiology

Place: Leyden, Netherlands.
General Secretary: Dr. H. C. Huizing, 182 Oostersingel, Groningen, Netherlands.

International Course in Paedo-Audiology

Place: Groningen, Netherlands.
General Secretary: Dr. H. C. Huizing, 182 Oostersingel, Groningen, Netherlands.

Pan-American Association of Oto-Rhino-Laryngology and Broncho-Esophagology

President: Dr. José Gros, Havana, Cuba.
Secretary: Dr. Chevalier L. Jackson, 3401 N. Broad St., Philadelphia 40.
Meeting: Sixth Pan-American Congress of Oto-Rhino-Laryngology and Broncho-Esophagology.
Place: Brazil. Time: 1958.

Sixth International Congress of Otolaryngology

President: Dr. Arthur W. Proetz, 3720 Washington Blvd., St. Louis.
General Secretary: Dr. Paul H. Holinger, 700 N. Michigan Ave., Chicago 11.

NATIONAL

American Medical Association, Scientific Assembly, Section on Laryngology, Otology and Rhinology

Chairman: Dr. Gordon D. Hoople, 1100 E. Genesee St., Syracuse, N. Y.
Secretary: Dr. Hugh A. Kuhn, 112 Rimbach St., Hammond, Ind.

American Academy of Ophthalmology and Otolaryngology

President: Dr. Erling W. Hansen, 90 S. Ninth St., Minneapolis.
Executive Secretary-Treasurer: Dr. William L. Benedict, 100-1st Ave. Bldg., Rochester, Minn.

American Board of Otolaryngology

President: Dr. Frederick T. Hill, Professional Building, Waterville, Maine.
Secretary-Treasurer: Dr. Dean M. Lierle, University Hospitals, Iowa City.

* Secretaries of societies are requested to furnish the information necessary to keep this list up to date.

American Broncho-Esophagological Association

President: Dr. Clarence W. Engler, 2323 Prospect Ave., Cleveland.
Secretary: Dr. F. Johnson Putney, 1719 Rittenhouse Sq., Philadelphia 3.
Place: Fairmont Hotel, San Francisco. Time: May 19-20, 1958.
Place: The Homestead, Hot Springs, Va. Time: March 8-9, 1959.

American Laryngological Association

President: Dr. LeRoy A. Schall, 243 Charles St., Boston 14.
Secretary: Dr. Harry P. Schenck, 326 S. 19th St., Philadelphia 3.
Place: Statler Hotel, Washington, D. C. Time: May 3, 1957.

American Laryngological, Rhinological and Otological Society, Inc.

President: Dr. Percy E. Ireland, 100 College St., Toronto, Canada.
Secretary: Dr. C. Stewart Nash, 700 Medical Arts Bldg., Rochester 7, N. Y.
Place: Mark Hopkins Hotel, San Francisco. Time: May 21-23, 1958.

American Rhinologic Society

President: Dr. Walter E. Loch, 9 Beechdale Rd., Baltimore 10.
Secretary: Dr. Robert M. Hansen, 1735 N. Wheeler Ave., Portland, Ore.
Annual Clinical Session: Illinois Masonic Hospital, Chicago, October, 1957.
Annual Meeting: Palmer House, Chicago, October, 1957.

SECTIONS:

Eastern.—Chairman: Dr. Joseph Sullivan, Toronto, Canada.
Southern.—Chairman: Dr. Mercer G. Lynch, New Orleans.
Middle.—Chairman: Dr. Paul M. Moore, Cleveland.
Western.—Chairman: Dr. Sigurd v. Christierson, San Francisco.

American Otological Society, Inc.

President: Dr. John R. Lindsay, 950 E. 59th St., Chicago 37.
Secretary-Treasurer: Dr. Dean M. Lierle, State University of Iowa, Iowa City.
Place: Fairmont Hotel, San Francisco. Time: May 17-18, 1958.
Place: The Homestead, Hot Springs, Va. Time: March 13-14, 1959.

American Otorhinologic Society for the Advancement of Plastic and Reconstructive Surgery, Inc.

President: Dr. Joseph Gilbert.
Secretary: Dr. Louis Joel Feit, 66 Park Ave., New York 16.

American Society of Facial Plastic Surgery

President: Dr. Irvin J. Fine, 505 New Brunswick Ave., Perth Amboy, N. J.
Secretary: Dr. Samuel M. Bloom, 123 E. 83rd St., New York 28.

American Society of Ophthalmologic and Otolaryngologic Allergy

President: Dr. Sam H. Sanders, 1089 Madison Ave., Memphis 3.
Secretary-Treasurer: Dr. Michael H. Barone, 468 Delaware Ave., Buffalo 2.
Place: Palmer House, Chicago. Time: October, 1957.

Otosclerosis Study Group

President: Dr. Joseph A. Sullivan, 174 St. George St., Toronto 5, Canada.
Secretary-Treasurer: Dr. Arthur L. Juers, 611 Brown Building, Louisville.
Place: Palmer House, Chicago. Time: Oct. 12, 1957.

Society of Military Otolaryngologists

President: Col. Wendell A. Weller.
Secretary-Treasurer: Major Stanley H. Bear, M. C., 3810th USAF Hospital, Maxwell APB, Ala.

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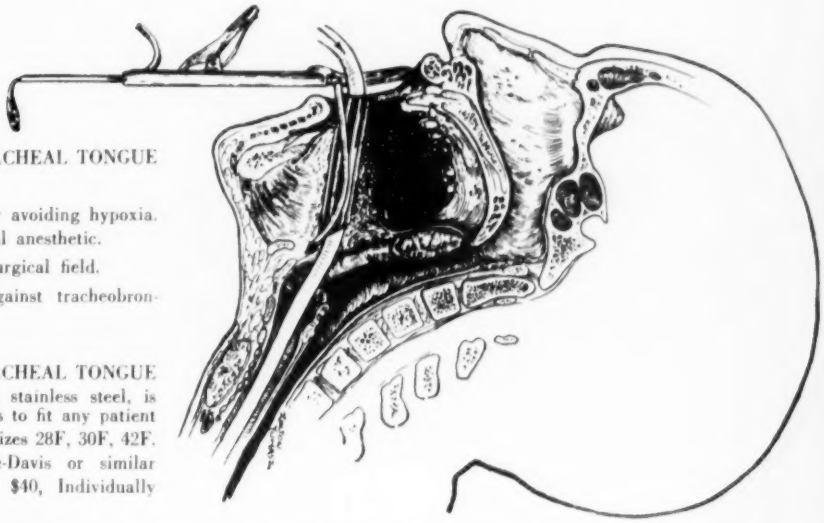

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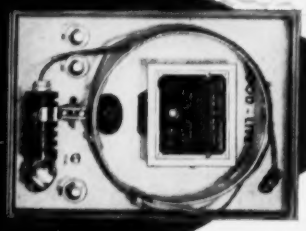

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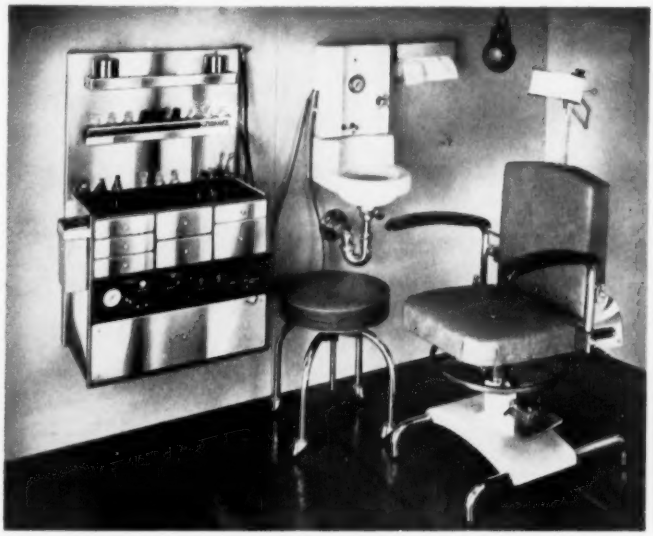

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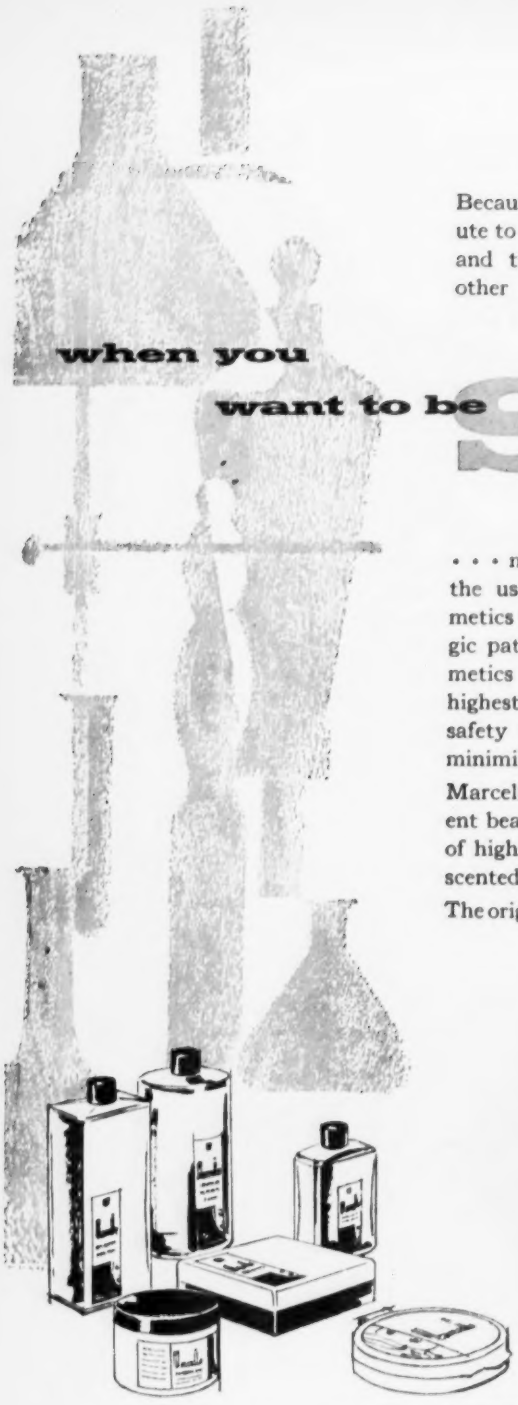

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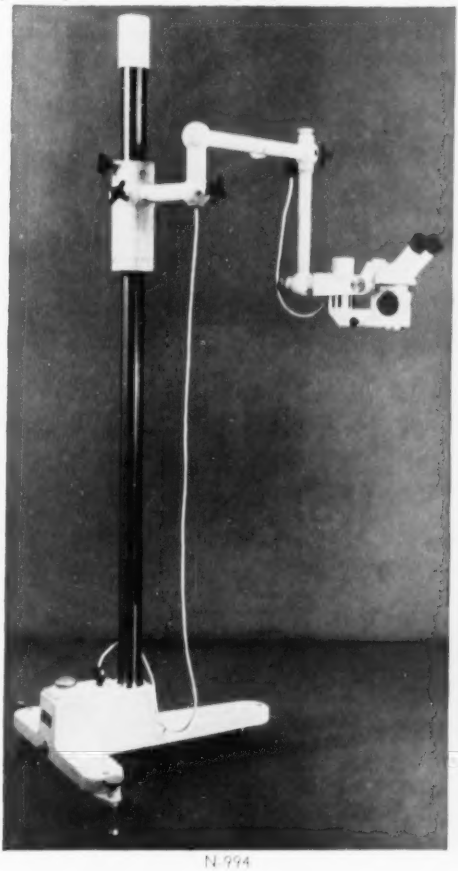

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